Executive Summary:
Motivation: Current practices in risk assessment and management for industrial systems are characterized by its methodical diversity and fragmented approaches. In retrospect these risk and safety paradigms resulted from diverse industries driven and limited by available knowledge and technologies. A change based on industry driven R&D work is needed.
At present the European Industry recognised their obligation to reconsider risk and safety policies, having a more competitive industry and more risk informed and innovation accepting society in vision. Therefore the large collaborative project IRIS is proposed to identify, quantify and mitigate existing and emerging risks to create societal cost-benefits, to increase industrial safety and to reduce impact on human health and environment.
Project Outline: The project is led and driven by industry to consolidate and generate knowledge and
technologies which enable the integration of new safety concepts related to technical, human, organizational and cultural aspects. The partnership represents over 1 million workers. The proposed project integrates all aspects of industrial safety with some priority on saving human lives prior cost reductions and is particular underpinning relevant EU policies.

Basic Concept: In short the concept of IRIS is to focus on diverse industrial sector’s main safety problems as well as to transform its specific requirements into integrated and knowledge-based safety technologies, standards and services.

Main S&T Objectives “For the Success of European Industry and the Benefit of European Society”

• Integrated Methodologies for pioneering Risk Assessment and Management
  A major enhancement in risk management is the integration of multiple risk assessment methods. The objective is a continuous risk assessment based on a combination of probabilistic (state-of-the-art) and measurement-based risk analysis.
  Expected Results: An integrated online monitoring system that combines the new paradigm integrating operation with risk management. Impact: 20% less down time of production

• New Knowledge-based Safety Concepts
  A general achievement of IRIS is to enable progressive continuous improvement through refinement of the risk identification, assessment and control processes due to building on knowledge already gained.
  Expected Results: Realization of a new knowledge based safety concept. Impact: accidents -50%

• Total Safety of Industrial Systems and Networks
  Such systems are based on integrated technical solutions through new models for industrial systems that take into account interdependencies during design and operation. They bring significant progress towards accident free networked production also in the increasing complexity of value-chain based production activities.
  Expected Results: Accident free networked production reducing the number of fatal accidents in Europe by 1/3 with potential on more reduction in future. Impact: Fatalities -33% (-1600 deaths)

• Knowledge and Technologies for Risk Identification and Reduction
  Innovative Risk identification and reduction has to consider the reassessment of exposure and vulnerability of environment, society, industry to the impact of natural, technological and man-made hazards. The implementation needs to provide the detection and early warnings of risk potentials before they become critical and whilst avoiding actions can be executed.
  Expected Results: Risk identification and mitigation tools fit for everyday practice. Impact: 50% less accidents.

• Online Monitoring with Decision Support Systems
  The realisation of former mentioned objective requires hardware and software for continuous risk assessment by online monitoring of the interactions in the industrial systems during their life cycle. S&T achievements are the development of decision support systems (knowledge-based system, self learning and artificial intelligence) for the evaluation of collected data as well as sensors, data management and a required cyber infrastructure.
  Expected Results: Embedded online risk monitoring systems for all industries
Impact: -20% down times, no loss of basic supply of power

• Pattern Recognition in Signal Processing
Detection of hidden attributes characterising evolving damages in materials and systems is the challenge. A general approach to detect unfinished forms of patterns will be developed as basis for decision making and early warning. This includes treatment of contaminated data and algorithms.
Expected Results: Basic tools for damage detection as basis for early warning
Impact: Reduced maintenance costs at equal safety level (-15%)

• Demonstration & Technology Transfer, Standardization & Training Activities
Expected Results: Wide spread technology demonstration, technology transfer, underpinning standardization and training activities are critical for broad application and guaranteed by the consortium represented by industry, main international and European stakeholders, specialized SMEs, research institutions and universities.

Project Context and Objectives:
1. Meta Concept

The concept established in Period 1 and 2 proved to be successful and has therefore been taken forward to Period 3 without major modifications (Details recorded in respective Work Documents). The project is structured into 8 work packages (WP1-WP8) which are each subdivided into 8 activities (activity 1-8). Some of these activities are of generic nature and apply to all work packages. They will not be repeated for each work package. This also supports the integrating character of the project. There will be a joint development with a joint approach and sector specific branches, which subsequently will provide feedback to the IRIS methodology.

ACTIVITY 1 Current Practice Analysis (partly WP specific)
(1) The objective of Activity 1 is to compile the knowledge regarding the state-of-the-art in safety monitoring and life cycle optimisation of industrial systems.
(2) Define the current technological level used in industrial systems (in chemical plants or nuclear power plants, etc.) and the current maintenance approach envisioned.
(3) Identify the (technical) obstacles for achieving a successful safety assessment and lifetime management.
(4) Identify the (commercial, political) obstacles to full exploitation of the aimed technology, if traditional methodologies are applied.

ACTIVITY 2 Definition of Inherent and Emerging Risks (generic and WP specific)
The second activity “Identification of Components and Attributes of the Risk Paradigm” involves the integration of the accumulated knowledge collected and organized in the previous activity with the aim to develop new generic definitions and descriptions of:
1. Risks variables, i.e. the risks and the risk factors that result to the occurrence of risks.
2. Exposure and vulnerability of the environment, the society, and the industry to the impact of natural, technological and man-made hazards.
3. Risk assessment methods and tools.
4. Monitoring instruments for the various risk related variables.
Accomplishment of the objective will bring the first output of the whole project, which is the development of
a shared platform for risk perception, communication and management for the key industries. This
platform, i.e. the risk paradigm, will include new generic definitions and approaches generated from the
integration of the current practices of the key industries.

2.1 Modeling of the Hazards (WP specific)
2.2 Determination of the Vulnerabilities (WP specific)
2.3 New Risk Paradigm (WP specific)
2.4 Sector specific Issues (WP specific)

ACTIVITY 3 Development of the Risk Management Procedure (WP specific)
3.1 Definition of Fragilities
3.2 Probabilistic Approach
3.3 Procedure Implementation
3.4 Sector specific Issues

ACTIVITY 4 Experimental Proof (WP specific)

ACTIVITY 5 Cross Sector Integration
The overall Objective of this activity is to ensure the full integration of all work packages within IRIS into
the IRIS methodology.
Detail Objectives are:
• Participation in the technology workshop of the other work packages
• Communication of the progress of the development work to the management and other WPs
• Delivery of respective background information to other development groups

ACTIVITY 6 Demonstration (WP specific)

ACTIVITY 7 Standardization, Internationalization
The seventh activity “Standardization, Internationalization” involves the transformation of the risk
paradigm to standards for risk assessment in the key industries at the European level. The
accomplishment of the objective will have profound impact on the industry and the society because of the
establishment of comprehensive risk management standards based on a holistic and innovative scientific
and practical approach. Furthermore, it will replace existing and incomplete standards and directives and
constitute a European and potentially international, generic and unified framework for managing risks in
the key industries.

ACTIVITY 8 Dissemination and Knowledge Management
The eighth activity “Dissemination and Knowledge Management” involves the dissemination of the results
and of the knowledge obtained through the work package both to and beyond the IRIS project participants
during and after the project’s completion. The accomplishment of the objective will raise the interest of
stakeholders in the key industries and public organizations and inform on the development of the
innovative risk paradigm and its use. It is anticipated that an early and continuous dissemination and
knowledge management will allow early evaluations and suggestions that can be incorporated to the
delivery of the rest of the activities during implementation and assist in the future the efforts to keep
updated the system.

Furthermore, the accomplishment of the objective will have an impact on the society achieving:
1. Acquisition of better knowledge and information about the risks of the EU industry that will increase the
   relative social perception.
2. Improvement of the dialogue between technology, industry and the society.

Transition of information to the society with regard to the industrial research conducted and of the current
developments to make it more accessible and understanding.

2. Detailed Objectives

The objectives specified in Period 1 and 2 are updated to meet the actual Project development. Due to the
soundness of the concept only minor updates were necessary. None of the previous objectives have been
deleted.

2.1 Specific Objectives: Work Package 1 (Nuclear Industry)

WP 1 concentrates on the needs of the nuclear industry dealing with the dramatic changes in earthquake
engineering. Re-thinking of the entire assessment process is anticipated. IRIS will contribute through:
- The definition of an integrated displacement based earthquake engineering procedure
- Enhanced modelling of structural response due to hazard
- Experimental proof of actual shear wall capacities at JRC in Ispra

Definition of an experimental procedure to determine inhomogeneous soil conditions (site-effects) at
NPP's.

The collaboration with the India partner BARC has been extended and their experimental campaign,
testing shear walls at shaking tables and pseudo dynamic will be included.

2.2 Specific Objectives: Work Package 2 (Chemical Industry)

WP 2 concentrates on plant aging in the chemical industry, where extension of lifetime is a key critical
issue. It will concentrate on:
- Identification of the physical properties representing aging
- Modelling of the respective hazard and vulnerabilities
- Development of a methodology to measure aging
- Experimental proof including mitigation measures at DOW in Germany

2.3 Specific Objectives: Work Package 3 (Construction Industry)

WP 3 concentrates on 2 major sources of hazard for the labour force. These are the identification of critical
threats and the subsequent warning procedure. The works will concentrate on:
- Work place security
- Individual predicting wear and devices for each worker
- Worker allocation system in hazardous areas
- Experimental proof of the development on site at BBT in Innsbruck

Take the opportunity to test IRIS developments at real structures. A selection of cases has been made including a bridge within the EGNATIA Highway in Greece, the Bridge 202 at the New Jersey freeway system and the Gi Lu Bridge in Taiwan.

- Application at most relevant structures for demonstration.

2.4 Specific Objectives: Work Package 4 (Mining Industry)

Work Package 4 concentrates on the subject of tailing ponds in the mining industry. The work will focus on:
- Safety estimation for tailing ponds under extreme complexity and non-homogeneous environment
- Measurement techniques to support risk estimation
- Experimental proof at tailing ponds at CUPRUM in Poland
- Contribution to Eurocode 7

2.5 Specific Objectives: Work Package 5 (Energy Industry)

WP 5 concentrates on the desire of the energy industry to use higher temperatures in their plants for efficiency and environmental reasons. The work is determined to:
- Understanding material behaviour at temperatures as high as 720 °C
- Development of a sensor system for monitoring of hot pipes
- Experimental proof of the monitoring system and the new material at RWE in Neurath

2.6 Specific Objectives: Work Package 6 (New Risk Paradigm)

WP 6 is devoted to the development of the new IRIS Risk Paradigm which will be the integrated basis for all industries. Its objectives are:
- Collect and harmonize the current practice cross over all industries
- Definition of inherent and emerging risks
- Development of the risk management procedure

2.7 Specific Objectives: Work Package 7 (Online Monitoring)

WP 7 concentrates on enabling the procedures developed in the previous work package in industry by the IRIS Decision Support System. It is devoted to:
- Create stable and fit for purpose monitoring systems
- Create the respective Decision Support Systems
- Establish the necessary knowledge for the civil multi non linear system identification procedure
- Demonstrate it at various occasions starting with S101 in Austria

The applications will subsequently be applied to all demonstration cases in the IRIS Project.
2.8 Specific Objectives: Work Package 8 (Risk Informed Design)

WP 8 takes care that the necessary feedback to standardization and support of the design process. The activities include:
- Creation and maintenance of relevant databases
- Remote sensing based datasets as base maps for detailed vulnerability assessment
- Preparing and conducting a CEN workshop
- IT tools for document exchange and management procedures

Project Results:
S&T Approach

The Strategic Concept for the research and development work within the IRIS project has consequently been continued from Period 1. After the successful current practice identification activities the Executive Board (EB) has setup a plan for execution in the direction of the application and exploitation of results. Developments in the various lines and industries have been screened on their potential to sustain and a clear focus has been put. This required a substantial sharpening of the detailed work plan and resulted in targeted allocations of topics to be elaborated by the various partners. The idea of creating a comprehensive cross sector methodology has sustained.

In consequence this strategy produced:
- The understanding that time is to be considered in any of the approaches as a standard attribute
- Degradation over time is a process that shall be described in a generic way to represent the development of state or condition at any discrete time of assessment
- Detailed rules for application in the various industries and domains are to be worked out always referring to the standard basic model
- The model needs to be standardised starting on European but extending to global level (from CEN to ISO) progressively

To implement this strategy the consortium particularly the Executive Board (EB) has taken the following steps:
- The current practice reports have been analysed and discussed
- The current practice has been demonstrated in various initial demonstration activities to get a closer grip on the practicalities and gaps
- Results, opinion or critics have been put into Work Documents (WD-xxx) which are available to every partner any time
- An update process constantly modified to work documents until consensus has been reached

This procedure has been proven to be very effective. It allowed to set priorities within the large number of S&T topics. This has been seen as the major advantage of Large Collaborative Projects in FP7. The flexibility and option of targeting forces has never been available to that extent before.

The major achievements resulting from this process are:
- The experimental part in in WP1 has been considerably extended to match the global initiatives in this field
The opportunity to perform demonstrations internationally has been strongly supported to give the issue more strength and momentum. The focus with respect to decision support has been shifted from instant assessment to prediction and optimization. The standardization process of the degradation model has been given highest priority because of the impact expected. The resulting demonstrations have been adjusted accordingly and became more global with activities in the US (Highway 202), testing in India (WP1 shaking table shear walls) and China (Gi Lu Bridge assessment).

Consideration of the socioeconomic impact
The introduction of time into the process allowed dealing with consequential damages. In case of industrial or natural disasters these are often higher than the initial impact. The focus therefore shifted to simulation including a Periodic update of an event allowing showing the consequences of accidents in industry (for example a toxic cloud of a chemical plant accident).

To show this a large demonstration project is prepared in Period 2 and will be performed in Period 3. Almost two years of preparation have been invested to organize the simulation of a major earthquake event with consequences on the nuclear, the chemical, the power and the construction industry. The description of this event is available as work document WD-348 in version 9 of April 2011. The lessons learned from this exercise will be used for the decisions how to complete the development work.

The overall character of the S&T approach in IRIS can rather be seen as top down management and does not follow the usual bottom up approach in research projects. Having the focus on practical development and real applications this is seem to be the best way of exploiting the available resources.

1. Work Package 1 (Nuclear Industry)
Introduction
The WP1 activities are split into three separate topics, all dealing with very relevant safety aspects. The major part of the activities is dedicated to the seismic risk, which involves practically most of the WP1 partners. The other two topics are: i) detonation/explosion risk and ii) structural health monitoring (SHM). The topic on the seismic risk is the one which benefits of the biggest attention in the WP1. The two other topics, however, are not less significant for the project, since they provide a strong interaction with other WPs. In particular, the “Detonation” topic is related to the subjects of the WP2 and the “SHM” topic is strongly inspired by the innovative technologies developed for the construction industry (WP3 and WP7).

Significant results
Risk of detonation of the radiolysis gas
In order to understand the failure mechanisms accompanying metallographic investigations were performed. The test pipes consist of a titan stabilized austenitic stainless steel X10CrNiTi18-9 which initially shows titan-carbide and a small quantity delta-ferrite distributed in the austenitic matrix. The pipes are solution heat treated. During high strain rate deformation, plastic work converts into heat which cannot dissipate and lead to adiabatic heating in localized regions. The increase of temperature leads to the decrease of flow stress. If this thermal softening effect exceeds isothermal hardening, the localization increases and leads to shear band formation.

During the tests on pipes with 60% of radiolysis gas, shear localization occurred along the planes of maximum shear and lead to the onset of multiple cracks and fragmentation. Due to the brittle character of
the shear fracture it has been postulated, that deformation induced martensite formation occurred along the shear bands. Rough measurements by a fluxgate magnetometer provide indications of the formation of martensite. Note, that this measurement method also captures the delta-ferrite which was measured to be approx. 1.4% in the undeformed condition.

In order to substantiate the above mentioned assumption investigations on an X-ray-diffractometer are in process at the time of research.

During the last period research on the material constitutive description was performed in order to understand the failure mechanisms:

• Material can be characterized by the Johnson-Cook model. The parameters are determined by several small scale specimen tests
• Full pressure profile including deflagration and overdriven detonation is necessary to analyze the structural response
• Influence of diameter widening on the pressure has to be considered.

During high strain rate deformation, plastic work converts into heat which cannot dissipate and lead to adiabatic heating in localized regions. The increase of temperature leads to the decrease of flow stress. If this thermal softening effect exceeds isothermal hardening, the localization increases and leads to shear band formation. During the tests on pipes with 60% of radiolysis gas, shear localization occurred along the planes of maximum shear and lead to the onset of multiple cracks and fragmentation. Due to the brittle character of the shear fracture it has been postulated, that deformation induced martensite formation occurred along the shear bands. Rough measurements by a fluxgate magnetometer provide indications of the formation of martensite. Note, that this measurement method also captures the delta-ferrite which was measured to be approx. 1.4% in the undeformed condition.

Beneficiary 08 MPA USTUTT participated in the blind pre-calculation for the “Shear Wall Test”.

Structural Health Monitoring of a containment building
The results of the project can be summarized in two groups.

• Influence of the prestressing force on the stress state (eigenvalues) of the structure.

Considerable effort is done to understand the influence of the prestressing force to the stress state and thus to the dynamic characteristics of the structure.

• Comparison between the dynamic characteristics of the structure calculated numerically and in situ (with the permanent monitoring system installed in Kozloduy NPP).

Considerable match of the dynamic behaviour of the structure is being reported between the partners from VCE, RISKENG and KNPP.

As a third and final period of the research, a correlation between the prestressing force (stress state) and the energy shift of the system should be determined. The relations should serve as basis for the SHM of the KNPP containment structure. Conclusions about the applicability of the developed methodology in practice are reported.

Seismic risk
Innovative testing facility for TESSH
As a consequence of the ambition of testing realistically thick shear-walls, the test design was revised and represents a major result of the second period. Due a delay in the contracting procedure (amendment has not been completed in time) the test could not be started early enough to complete them within the
schedule. Testing has started and the first specimen has been completed and the entire consortium was able to watch this event (March 5th 2012).

Shear-wall design
The design of the shear-wall is representative of RC structure of existing NPPs. Special attention had to be paid to the design of the wall’s boundaries in order to avoid spurious failure modes. The first part of the third period mainly consisted in performing of the experimental campaigns that were prepared during the first two periods: TESSH, BARC and SMART. In the last part, the test results were analysed by IRIS partners.

2. Work Package 2 (Chemical Industry)
Introduction
During the first part of the project work was concentrated on gathering data for safety assessments and risk reduction measures. During period 2 the focus of experimental and analytical investigations was lying on in-situ investigations of a large-scale safety relevant piping system of a chemical plant. Besides these deterministic approaches also probabilistic investigations were carried out. The identified risk at this chosen system is High Cycle Fatigue (HCF). To avoid failure, vibration amplitudes should be reduced. Since the supporting structure is vibrating as well in the upper part of the system, not dampers but vibration absorbers could be used such as
- Passive Vibration Absorbers (task of partners MPA USTUTT, GERB, BfB, Dow) and
- Active Vibration Absorbers – so called AVA (task of partners WBI and Dow) were tested. Further results are given below.
- New activities were performed by Partner ERF creating a rheological semi active mass damper for risk reduction in structural components of chemical industry and power plants. A first design calculation was discussed with partner MPA USTUTT for implementing at the Mock-up of partner MPA USTUTT.

Within the third period, the damage assessment based on vibration data was performed using several neural net topologies. In order to validate the applicability of the neural network approach, data from bridge object S101 (provided by VCE) was employed. For several cases, the NN’s were trained using this data and the results were investigated in order to detect/evaluate the state of damage. In particular, the work was concentrated on trying to assess the progress of the damage state.

Significant Results
Subject ‘Passive Vibration Absorbers (PVA)’
Now, several solutions for the design of a passive vibration absorber were presented.
The goal in WP2 of Partner Fraunhofer IZFP was the development of a system structure for hot spot monitoring on Plug Flow Reactor at DOW Stade based on wave guides. Concept demonstrates measurement principles for damage visualization by use of SAFT-algorithm. A dedicated sensor actuator network was developed and acoustic wave guides were fitted to the titan elbow. Based on this concept an explosion proof monitoring system for the elbow at the plug flow reactor was developed.
Work was focused on design calculations and planning the demonstration phase with the following topics:
- Agreement in all details on the demonstration-measurements has been achieved.
- A solution with ex-protected transducers for measuring forces was found.
- The measurement transducers were specified.
- A final type of vibration absorber to the piping system was designed.
The use of vibration absorbers for piping is rather new while it is known for civil engineering structures like tall pedestrian bridges and high rise buildings. A piping system such as the investigated large scale one – usually is supported in Chemical Industry by a tall structure fixed at the base. As a result, the steel building stiffness decreases with height. Furthermore large piping-elbow forces act at the top of the building, which lead to large vibration amplitudes. Since both piping system and supporting structure exhibited these large vibration amplitudes, dampers or shock absorbers placed between them would prove ineffective. Therefore the investigated use of vibration absorbers is an appropriate tool of risk reduction in the sector of Chemical Industry and plant engineering. Piping systems are complex 3-dimensional structures usually with many and complicated mode shapes. The design of a dynamic vibration absorber has to consider the specific requirements of the piping systems in question and should enable easy and safe installation.

The optimal mounting location in regard to vibration reduction is not always available. Therefore the dynamic absorber should work in many positions. The selected design for the investigated large scale piping system works analogous to the mock-up test with a defined mass that is connected to a member. The bending eigenfrequency depends on the stiffness of the member which in turn depends on the free and vibrating length. For tuning purposes this length is adjustable.

For energy dissipation the vibrating mass of the dynamic absorber moves in a highly viscous fluid. The absorber can be attached to the pipe in every position and the direction of the absorber vibration adapts itself to the motion of the pipe.

Vibrating mass, stiffness and damping were chosen in accordance to known optimization criteria for harmonic and random vibrations. Based on measurements and finite element calculations the modal or resonant mass of the structure was determined to be about 7000 kg. With a mass ratio of 5% the total vibrating mass of the absorber was 350 kg. The optimal damping ratio of the absorber is about 11%.

In the discussed case two absorbers with half the required vibrating mass were designed to minimize the additional weight attached to one point of the pipe.

Vibration absorbers can be found in easily excitable structures as street and pedestrian bridges, terraces, chimneys or long-span floors. When excited with frequencies close to a natural frequency these usually low dampened structures respond with large deflections, which are often sensed as uncomfortable, but which are sometimes also dangerous and service life reducing. Large piping systems in power or chemical plants are also low damped, highly flexible and complex structures. The increase of system damping is often the only efficient way to reduce system responses to all kinds of dynamic excitations. Viscous dampers are often used for this purpose but they require a stiff support point. Especially in tall chemical piping structures these stiff supports are missing and therefore the use of passive dynamic vibration dampers with efficient damping capability is a promising approach to increase system damping and to solve the vibration problems in these systems. In general dynamic vibration absorbers consist of a mass that is elastically connected to the main structure by springs or pendulum systems. Additional dampers acting in parallel to the springs or pendulums dissipate the vibration energy and widen the working range of these elements. In case of large structures and depending on the critical mode shape to be dampened several absorbers can be installed along the structure to work in parallel.

Subject ‘Active Vibration Absorbers (AVA)’

The AVA performed very well and reduces the amplitudes up to 60%
After the successful initial operation of the AVA in the chemical plant, a long-term test was performed to assess the reliability of the active absorber. For this purpose, all electrical components are mounted in an electrical cabinet. The previously used rapid prototyping control-system is replaced by a compact real-time control system. To ensure the required explosion protection the control cabinet and the housing of the AVA are purged with air, while simultaneously monitoring the internal pressure. Falls the pressure difference between inside and outside below a defined threshold, the entire power supply of the electrical cabinet is turned off.

In the measuring station of the chemical plant the operation of the AVA was controlled. This was performed by means of vibration sensors on the pipe-reactor, which signals were conducted to the measuring station. While the absorber was running the existing vibration level was significantly lower than with switched off absorber.

Issues during long-term test:
During the long-term test in the chemical plant some issues with dropouts of the AVA occurred. These dropouts followed a specific pattern; the drop-out took place every 3.1 days (228 ms). The used real-time controller could be determined as the source of this malfunction. To remove this malfunction a reboot of the real-time controller was necessary. Since the manufacturer of this device was not able to solve this problem, an interim solution was implemented: A reboot of the real-time controller was initiated automatically by a time switch every Monday, Wednesday and Friday. The Active Vibration Absorber was hereby deactivated for a period of approximately 1 minute and restarted subsequently. During the subsequent testing phase further stops occurred. These stops were randomly distributed, without an obvious pattern. It was assumed that these stops appeared by means of loose contacts in the electrical cabinet due to the high vibration level at the location of the cabinet. E.g. a loose contact at the connection of the vibration watchdogs would cause a stoppage of the AVA.
To solve this problem it was necessary to observe the acceleration- and control-signals of the AVA over a long time period to find a correlation between stoppage and the measurement signals before the stop-incident. Due to the fact that a remote-monitoring of the system via remote internet-access was prohibited, a permanent logging of the measurement data was performed, together with a later offline data-transfer.
As further measurements of the IRIS-Partners VCE, IZFP and MPA, on the pipe-reactor were planned, the design of a new electrical cabinet became necessary. This cabinet contains the existent electronic components and the electronic components of the mentioned IRIS –Partners. The design, the construction and the wiring of the new electrical cabinet was done by WBI.

Subject rheological semi active mass damper
Acceleration and deflection are evaluated at the mounting position of the damper. For the first resonance the simulation shows a theoretically achievable acceleration reduction of about 70% with the passive ER-SAMD system (ERD turned off) and about 85 % with the activated ER-SAMD. In the second resonance the simulated passive reduction is about 60 % while in the active mode again about 85 %.
The snap back simulation shows the decrease of decay time by the application of the ER-SAMD. The decay time of the non-damped mock-up is about 60s, until the vibration is reduced to less than 1% of the initial value. This decay time decreases to about 7s with applied ER-SAMD in the passive (control OFF) mode and about 1,5s in the active (control ON) mode.
As a part of the project, a semi-active vibration absorber is developed. At the beginning of the project
Piezo technology was used. This was superseded by electrorheological technology. First, several concepts of adaptive tuned mass dampers were created. These concepts have been presented to the project partners. A demonstrator was to be dimensioned in January 2011 and then constructed and tested. In order to determine the correct dimensions of the demonstrator, simulations were performed. The demonstrator was then constructed and tested at the MPA Stuttgart in 2011 and 2012. The results of the simulation showed that adaptive solutions do not use the full potential of the electrorheological technology. One of the main features of the electrorheological technology is its very fast response. A configuration in which the voltage at the electrorheological fluid changes slowly is not optimal. Thus, following operating principle was developed:

Springs and damper are arranged in parallel. They are installed between the piping and the reactive mass. Sensors are used to measure the acceleration of the piping and the position of the damper rod. The signals of the sensors are fed to a controller. The controller reads these signals and applies an according voltage to the damper. The performance of the controlling algorithm is very important.

Work performed on Damage assessment by ANN’s

In particular, the work was concentrated on trying to assess the progress of the damage state. Concerning the training input data, the measured (experimental) data was analysed and time slots of data corresponding to different damage states was extracted. For each assumed damage state (contiguous time slot), the training was performed separately for two selected measuring positions on the bridge. The training outcome (the corresponding weights of the multivariate polynomials) for the two positions was compared by means of an appropriate damage distance formula.

Subject Local Wall Thinning:

The tested scenario is that of a small diameter-branch being attached to a large diameter piping as it is typically in a huge number of piping systems (e.g. measurement connections, etc.). The piping is excited by resonant excitation as it occurs during earthquake loading. The large diameter piping, vibrates with a low frequency due to which the branch can fail by crack growing or ratcheting. The expectancy of lifetime is reduced because of the local wall thinning in the elbow of the branch.

3. Work Package 3 (Construction Industry)

Introduction

The risk management in the construction industry does not only comprise the structures itself but also the safety of workers. Nevertheless the integrated IRIS approach allows applying a basic joined approach. The condition of any element or activity can be described by fragilities. Fragilities degrade over time as explained earlier. The consequences are either a maintenance and mitigation plan or actual warning of workers in case that the risks pass certain thresholds. A work performed in WP3 therefore covers a major number of activities by various partners.

The “Accumulative Energy Function” developed in Period 1 has drawn major attention on global scale. It has been found extremely attractive everywhere but the change or step forward is considered to be too radical in order to be accepted without reservation. Major agreement has been found with engineers familiar with hydro or aerodynamics because of the similarity of the phenomena. The typical civil engineer is per education not aware of the scientific background.

Much of the work done in work package 3 (WP3) is actually displayed in the two publications on the multi non-linear condition model and damping in experimental and engineering practice.
Non-linear development of a structure over time

The methodology developed in Period 1 and described in the previous report has been applied to several real structures where data are available over a considerable period. The application of the methodology to these data has shown a function of degradation which supported the idea that a generic model to describe this function would be desirable but also visible.

Significant Results

The most significant result is the development of a generic degradation model as developed in concept during the S 101 bridge demonstration and fully implemented after the international highway 202 demonstration in New Jersey. The immediate acceptance and attention of the international research scene proofed that development has fully hit the target. The decision to make it a basis for standardisation has immediately been taken. Details can be found in work document WD-220.

The results developed by the University of Braunschweig on workers allocation and the University of Torino on scaffold safety have been taken up by industry already which makes them significant. Both approaches are mature and were demonstrated in Period 3.

The third Period was characterized by standardisation and demonstration. The resources were mainly focused on:
- Defending the proposed degradation curve against the interest from other groups (i.e. CEN TC 250). This is seen to be necessary as due to the huge impact interest beyond technological progress is identified. The approach is characterized by the production of a major number of examples to show how generic the model can be applied. It will directly be used at a road section in Austria where all type of structures is contained. This will produce strong arguments to defend the approach
- The workers safety and allocation issues were jointly demonstrated at the Tunnel of BBT directly after the Summer Academy in September 2011. A respective shift of budget to create this demonstration has been agreed by the Executive Board. All participants of the Summer Academy were invited to this demonstration.

4. Work Package 4 (Environmental disasters in the mining industry)

Introduction

Research within the WP-4 was mostly devoted to development of numerically advanced methods and procedures addressed to risk assessment/management in the mining industry waste storage and disposal. These investigations have included the following research topics:

- Enhancements in a computerized slurry flow model, based on the Navier-Stokes equation formulated in 3D; Preliminary studies on slurry wave velocity and thickness’ distribution over the adjacent terrain surface.
- Dams’ failure including the effect of the acceleration of the dams’ sliding blocks and their permanent movement due to selected recorded accelerograms has been obtained based on the Newmark method.
- Environmental risk assessment due to soil/water contamination as well as the human exposure to the contaminated substances have been completed.
- Risk management and risk reduction organizational measures have been completed.
- The research on cutting-edge numerical modelling techniques including advanced constitutive model of soil behaviour and a coupled 3D stochastic finite element formulation has been done.
- More case studies from the Murcia Province (Spain) were investigated and described.
- The preparedness against strong earthquake events has been demonstrated.
The enriched knowledge on the subject was shared with the IRIS project participants during Summer Academy held on September 2010 in Zell am See, as well as during inter-WPs meetings. For instance, the integration of risk assessment and management practices developed in WP-4 with the risk paradigm methodology suggested by WP-6 partners has been commenced. Furthermore, the Risk Register concerned with tailings ponds case study has been developed. The collected data on the subject indicate a significant progress in analytical/numerical tools development and in integrating the partial risks which finally create the total risk value, characteristic for a given waste facility.

Since the main objective of the WP-4 research is to elaborate a combined multi-risk-oriented analysis, the research during the Period 3 focused on the inter-correlation between events and their possible conjunction. The inherent and emerging risks have been also identified and generalized in a comprehensive risk management procedures supported by the results of the real storage structures surveillance and monitoring.

Enhancements in a computerized slurry flow model, based on the Navier-Stokes equation formulated in 3D and preliminary studies on slurry wave velocity and thickness' distribution over the adjacent terrain surface. Based on the fundamental relationship for IRIS Risk Paradigm for rough estimates of risk we may separate the probabilities of different failure modes occurrence with corresponding costs of consequences. In this research, 116 geotechnical dams' cross-sections have been characterized and deterministically/stochastically analyzed from point of view of their structural stability and consequences of failure. Since deterministic safety factors' assessment results indicated large variability of its value depending on the section location these data have been treated as a population of random variable samples which periodicity could be verified using so called autocorrelation analysis, which in turn enables to specify numbers describing the “memory” of the process and the mutual (in)dependence of the elements (safety factors). The assessed autocorrelograms (autocorrelation functions) have been obtained at only one selected 2 km length of the dams:

Based on the obtained results, the dams' cross-sections of the highest potential for breakage have been identified. The identified location and the width of the highest potential breakage permit assuming the model of slurry/water flow from the damaged section of dams. At the moment, the required computer code addressed exclusively to this 3D problem is in the first stage of the development, i.e. the assumptions and the preliminary runs have been conducted based on transient unsaturated flow formulation. The tailings deposit is represented by the Bingham body. The most important expected results obtained from the performed computational analysis based on above presented principles are:

1. The velocity of tailings movement.
2. The final range of the movement.
3. The intermediate and the final area of terrain surface covered by the liquefied tailings slurry.
4. 3D topography will be involved in the analysis.
5. The volume of tailings/water released.

Due to lack of knowledge on the problem parameters statistics as well as lack of closed analytical solution, presently it is difficult to analyze the problem as a stochastic process. For a time being the problem of
Environmental risk assessment due to soil/water contamination as well as the human exposure to the contaminated substances have been completed. A practical approach for environmental risk assessment has been proposed. This approach begins with establishing a field sampling and monitoring program for determining the magnitude and the lateral and vertical extent of possible contaminations. These programs include the collection and analysis of a large number of sediment (soil) cores, ground water, surface water and air samples taken from the nodes of the established measurement grid. The collected analysis results will indicate the areas of the contaminants of concern existence, their toxicity, fate and transportation routes. Usually the level of contamination varies throughout the site ranging from below detection to the ultimate (accepted by the regulatory agencies and other legal documents) level $F_{ult}$. The overall risk assessment has to include the evaluation of both the risks to the environment and the risks to human health posed by the release of chemical agents from the tailings/wastes storage facilities. The
latter one relates quantitatively the concentration of a contaminant in an exposure medium (air, water and soils) to its toxicological effect in a biological organism through multiple exposure pathways. The determined value may be used further to estimate an acceptable exposure level, if a such information has not been available in being in force regulations yet. This may be done using so called risk-based action levels RBALs which are the ultimate limits for human and environment exposure to contaminants of concern requiring the appropriate remedial action to be undertaken.

Risk management and risk reduction organizational measures
Since the loss-of-life risk is the most important parameter which may be used for the failure consequences evaluation, particularly when the acceptable likelihood of the dam failure event is under consideration, the following approaches were utilized:
• the approach based on the F-N (Frequency/year – Number of fatalities) curve, also known as Farmer’s diagram, and
• the Location Specific Individual Risk (LSIR) which described quantitatively the annual frequency of events resulting in fatal injury of a person located at the given map’s coordinate.

Based on the available information (e.g. Eurostat statistics on time expenditure by the people) the most important factors influencing the mortality have been also involved in the analyses, among them:
• different age classes: infants, children, adults and seniors;
• different exposure states, e.g.: at home (ground floor or upper floor), in buildings other than home (at ground floor or upper floor), travelling by car, outside walking, etc.;
• time classes: day or night;
• classes of buildings;
• types of emergency instructions: e.g. evacuate or move to the upper floor;
• awareness states: sudden versus anticipated emergency.

The research on cutting-edge numerical modelling techniques including advanced constitutive model of soil behaviour and a coupled 3D stochastic finite element formulation
This report has highlighted the progress achieved in WP-4 in a probabilistic strategy for assessing the reliability of, and risks posed by, soil slopes. This has included recent state-of-the-art developments in this subject area. The following processes appear central to the effective probabilistic assessment and monitoring of tailings dams' structural stability:
An effective strategy for characterising the statistical properties of materials in-situ, including correlation distances and distribution functions.
A sophisticated constitutive model of soil behaviour that accounts for the shear-volume coupling in, and relative density of, soil deposits.
The capability to conduct three-dimensional finite element modelling within a stochastic framework.
In order to analyse slope failures by the finite element stochastic analyses, one needs to choose a constitutive soil model which is realistic and can accurately mimic sand behaviour ranging from liquefiable to strongly dilative. Therefore the double-hardening soil model Monot has therefore been employed in this project to model the soil behaviour in finite element computations of slope stability using random field theory to model the soil variability.
Monot is a double-hardening elastoplastic constitutive soil model which was developed by Molenkamp and which, as implied by its name, can be applied to problems involving monotonic loading. The model is expressed in terms of the effective volumetric and deviatoric stress invariants s’ and t, and their
corresponding strain invariants \( a \) and \( b \).

The parameters’ calibration sequence, proposed by Hicks, in which one or two parameters are isolated at every step, then calibrated using well defined stress paths and then eliminated from the calibration process. It is easier to carry out the calibration based on the results of drained triaxial tests; but, for accurate simulations of the pore pressures, which are important in the current research, it is recommended to use undrained triaxial test data as well. Therefore, drained triaxial data were first used to calibrate the model parameters, and then the calibrated parameters were checked against undrained data for further adjustments if needed.

For solving boundary value problems, incorporating the double-hardening constitutive soil model Monot, the MONICA (short for “MONot Incremental Computer Algorithm”) general purpose finite element computer code has been developed. It is based on the initial stress algorithm of Zienkiewicz et al., in which loads or displacements are applied incrementally and in which the stiffness matrix is assumed to be constant within an increment. For each increment, those stresses which violate the yield criterion are redistributed as internally applied excess nodal loads and an iterative procedure is performed, until the change of displacement in two consecutive iterations becomes less than a specified tolerance thereby indicating convergence. MONICA has five distinctive features as follows below (Hicks, 1990):

- Elastoplastic stiffness matrix,
- Subincrements of strain,
- Stress region estimate,
- Error loads,
- An improved no-tension correction.

Additional case studies from the Murcia Province (Spain)

The IRIS Risk Paradigm has been applied here specifically to abandoned and unconfined tailing ponds from metal extraction activities carried out under semiarid Mediterranean climate, Mining District of Cartagena-la Unión.

Risk identification:
- Geotechnical, geological, geochemical, geophysical and hydrological techniques were used to identify the risks in the whole Mining District of Cartagena-La Unión.

Risk inventory:
- The parameters affecting the identified risks were listed (acidity, heavy metal content, organic carbon and inorganic carbon content etc.), which was used in the design of reclamation actions.
- Two representative tailing ponds were selected, where reclamation techniques for risk reduction were applied.

Risk assessment:
- A detailed risks assessment was carried out in the selected tailing ponds, using the above mentioned techniques; including:
  1. State of degradation (physical, biological and chemical degradation)
  2. Metals in particle size fractions
  3. Concentration and percentage of soluble and available metals.
  4. Metals in plant tissues

Risk mitigation and prevention strategies:
- Pilot experiments were carried out in order to select the proper mitigation and prevention strategies.
- In order to risks mitigation, reclamation activities at large scale were designed and applied in the
selected tailing ponds. These activities included application of amendments (organic and inorganic) and phyto-stabilization.

Risk monitoring:
In order to evaluate the effectiveness of the reclamation activities, a monitoring strategy was designed. This monitoring includes a periodic sampling of the tailing ponds (every 6 months) and the analyses of the parameters evolve in the identified risks.

The general objective of this report is to show an effective methodology for environmental risk assessment and environmental risk reduction in mining tailing pond using amendments and phyto-stabilization.

The preparedness against strong earthquake events has been demonstrated.

General Presentation
In the collaboration of the Institute of Energy Research and Modernization-ICEMENERG SA Bucharest (Department of Environment and Ecotechnologies) with SC Complex Energetic Rovinari SA, for the international FP7 project “European Integrated System-Industrial Risk Reduction Project. CP-IP 213968-2 IRIS, has been provided an earthquake simulation in Romania and demonstrating the intervention in this situation of each partner from the project. This simulation took place in parallel with the real-time simulation in Hungary, Szekszard city.

General Goals
- Prepare the personnel on the work places.
- Knowing the vulnerabilities to disasters that may occur in an earthquake;
- Checking the organization of the cooperation of all participating forces.

Specific Goals
- Involve operational personnel in organizing and conducting intervention operations until the arrival of the intervention team in case of earthquake at slag and ash deposit,
- Alerting service for emergency situations, by announcing Chief Dispatcher,
- Intervention with the devices (vehicles) and tools (shovels) endowment.

5. Work Package 5 (Energy Industry)

Within the second reporting period some important changes have resulted in WP 5. Two new partners have joined the work package: BARC and CVS. Their work has to be integrated into the planning of WP 5. CVS is dealing with high temperature creeping and BARC is working on reliability analysis and probabilistic fracture mechanics of pipes. Both objectives fit very well into WP 5.

One member of WP 5 changed its research objective. ERF Production stopped the development of piezo-fiber transducers. Therefore, the company moved from WP 5 to WP 2. In WP 2 the company tries to develop an ERF-damper.

The main research object in WP 5 is the bypass at RWE power plant Neurath. For operational reasons this bypass was relocated from Block D to Block E. This means that all work already done at the old bypass in Block D has to be repeated for the bypass in Block E.

Significant Results

RWE: Provision of bypass and guarantee of safety integrity level
WBI: Measurement and analysis of bypass
The results of the measuring campaign of WBI are documented in a report consisting of 6 text pages and 176 pages of appendices. The simulation results are documented, too. Only a few parts of these results are given here together with results of comparison of measurement and simulation. For details please see full report which was published as a deliverable.

Conclusions
The absolute values of measured and simulated natural frequencies fit quite well. The mode shapes, however, did not fit at all! There are several reasons for this:
FEM simulation with ROHR2:
- The masses of the fittings (valves) are unknown. All fittings are modelled with 255 kg each;
- no information about “other” masses which can be assigned to the piping systems (e.g. small parts, piping systems including fittings branching off, etc.);
- no information about the total mass of the condensation water in the bypass during the measurement (bypass non-operating);
- no exact knowledge of the boundary conditions (anchor point on stage is not really fix, influence of the DN1150 piping system on the subsystem? stiffness to be applied with de-coupling).
Measurement:
- Measurements reflect the behaviour of only a small part (bypass) of the global system? problematic to draw conclusions on the global mode shapes;
- measuring data for DN200 available, but only to a little extent. Furthermore, measurements were carried out on the insulation. Summing up, a detailed evaluation of the said data are fraught with difficulties. However, evaluation should still be carried out;
- in case such evaluation should not lead to target-oriented results an additional measurement should be considered. This however with adaptation of the analysis model? analysis of the global behaviour of the global system with consideration of the system limits (anchor point at the stage, coupling of DN200 to DN1150)

MPA: FEM analysis of Bypass in Block E
For the reason of studying malfunction simulations, e.g. blocked or inclined hangers as planned for the demonstration test, the investigated bypass will be calculated with the multiple purpose Finite Element (FE) code ABAQUS. The FE-model is now ‘ready to go’ for test accompanying analyses. All pipes, even the straight ones are modeled with ABAQUS ELBOW31 elements which take into account cross-section ovalization and warping. In comparison to technical piping codes like ROHR2 it is on the one hand more complicated modeling all typical piping components like springs and other hangers with ABAQUS, but on the other hand a realistic ovalization behavior will be provided instead of using flexibility-factors like in ROHR2. Also several subroutines for constitutive laws as such as creeping are available for nonlinear time history dynamic integration.

IZFP: Installation of sensor network at the bypass, tests of the network
First initial tests showed that the signal noise ratio could be improved to a large extent by averaging. For this measurement, the receiver tube length equalled approx. 1.0 m with a distance between the actuator and the sensor of 1.9 m without flow and during flow of steam with 280 °C. Significant changes in
the receiver signal could be detected especially during warm up of the bypass. Furthermore, the first campaign of the field experiments used the undamaged bypass for reference measurements over a time period of 24 h and full pressure to calibrate the measurement system and to adapt the operating parameters to the measurement task. The results are currently under evaluation. The next planned measurement campaign will be reference measurements to estimate the influence of the steam flow more specifically. The valves will be closed, half open and open for certain periods of time. The overall time of the measurement campaign is planned with 90 h operation time at the bypass.

ISC: Langasite sensors

Further development and improvement of the high temperature ultrasonic transducers based on langasite single crystal transducers capable to work in a temperature range up to 900 °C has been performed by Fraunhofer ISC. Especially the glass solder which is used as electrical insulator against the metal steam pipe was adapted for the use on the bypass demonstrator at the project partner RWE. The surface temperature (500 °C) of the bypass pipe was measured exactly in June 2010. This measurement is crucial for the development of the glass solder because the glass transition temperature has to be adapted exactly to the operation temperature of the transducer.

For the preparation of the first tests at the bypass a test arrangement of the application technique has been made in the laboratory.

During the application of the transducer on the steam pipe temperatures of around 650 °C are necessary to melt the glass solder for mechanical strong contacts. This high temperature may change the microstructure of the pipe steel and should be avoided. For this reason some more experiments are necessary to show the effects of higher temperatures on the steam pipe material which will take a while. Nevertheless, a second conception of assembling the high temperature transducers has been developed. In this case glass solder with a lower glass transition temperature is used only for the ultrasonic wave coupling to the pipe surface.

The advantages of this design are:
- No glass solder melting at higher temperatures (800 – 900 °C) necessary, no additional thermal stress for the steam pipe;
- maintenance / change of the transducer during operation of the power plant possible;
- free design of the geometry and positions of the transducers on the pipe ("arrays").

CVS: Flexibility analysis of pipes

Piping flexibility or stress analysis is a term applied to calculations which address the static and dynamic loading resulting from the effects of gravity, temperature changes, internal and external pressures, changes in fluid flow rate and seismic activity. Codes and standards establish the minimum requirements of stress analysis. The purpose of piping stress analysis is to ensure:
- Safety of piping and piping components;
- safety of connected equipment and supporting structure;
- piping deflections are within the limits.

Within the IRIS project the use of the piping flexibility analysis is not limited by the design needs only, but could also be utilized for the purposes of industrial piping monitoring and improvement of the life prediction.
Assessment.

Benefits of piping flexibility analysis in frame of monitoring systems are:
- Fast run tool;
- model could be easily adjusted to the measurement results;
- accounting of different types of loads (static, dynamic, operational, external, etc.);
- check of compliance with different codes;
- modeling of small non-linearity for the boundary conditions.

Numerical modeling of the passive vibration absorber within the dPIPE program for design optimization

This study was performed on the base of the mock-up at MPA Stuttgart. A sinusoidal sweep excitation with variation of frequencies from 10 to 1 Hz was applied as input loading.

The following parameters of the passive absorber that have influence on the piping response were varied in the frame of sensitivity analysis:
- Variation of rod length (from 400 to 1000 mm);
- variation of oil damping (from 2 to 10 %);
- accounting for possible collisions inside of VA.

Influence of sustained and expansion loads on lifetime prediction of piping components operating in creep range

Nowadays, conventional power plants designed in Russia as well as in European Countries in 60 – 70 have exhausted their original design operation resource set as 100000 hours. In some cases operating time reaches the value 250000 – 300000 hours. One of the most common failure modes for elevated temperature piping working in the creep conditions is initiation, growth of cracks in pipe bends that finally leads to the failure. Failure of bends is much more dangerous than appearance of cracks in the piping joint welds or tees due to size of affected areas.

Actual industrial practice for the life extension of power piping consists of three parts:
- Visual inspection and examination of piping and piping supports system;
- NDE: making of replicas, measuring of wall thicknesses; creep control for out-of-roundness for bends and straight pipes;
- stress analysis of piping with specified material properties, based on the actual wall thicknesses and exact operation history (different from design!).

From the previous studies there was conclusion that “with pipe bends, attention must be paid to imperfections of the cross-section, such as out-of-roundness and different wall-thickness, and their interaction with the internal pressure as well as bending and torsion moments.” Actual design piping codes and standards do recognize creep damage as governing failure mode for high temperature piping, but:
- for the strength calculation it is not possible explicitly reflect long-term behavior of components operating in the creep range due to assumption of linear-elastic material properties;
- influence of out-of-roundness for pipe bends on stress state is not included in EN 13480 – “Metallic
industrial piping”, nor in American ASME B31.1 and B31.3; performed earlier studies have shown significant influence of ovality in conjunction with the internal pressure on the stress state of piping elbow. An actual evaluation focuses on the assessment of pressurized pipe bend with additionally applied bending moments.

Conclusions
1. Out-of-roundness and bending moments are significant contributors to the stress state of pipe bends and hence in the creep cumulative damage. Neglecting of these factors could lead to big uncertainties in the remaining life prediction.
2. For the creep damage sustained loads are more important than thermal expansion loads.

BARC: Reliability analysis
Probabilistic Fracture Assessment (PFM) [1-4], which combines fracture mechanics and structural reliability, is a widely used tool for evaluating reliability of piping structures in Nuclear Power Plants (NPP). These reliability estimates can be used for Probabilistic Safety Assessment (PSA) of the NPPs. Operating experience of the boiling water reactor suggest that Inter-Granular Stress Corrosion Cracking (IGSCC) is dominating crack growth mechanism [3]. These cracks have led to leakage in piping, however large break failure is not observed. Hence to estimate the breakage probability in the piping analytical methods based on structural reliability theory is needed. The IGSCC crack growth is function of many parameters such as sensitization of material, stresses and water chemistry. Further, failure depends upon flow stress of material. In PFM, all these parameters are considered as random parameters and uncertainty present in these variables is modeled by using probability density function.

In the present work probabilistic fracture assessment of Advanced Heavy Water Reactor’s (AHWR) down-comer piping is carried out. Leakage and breakage probability of down-comer is calculated for 100 years. It is found that leakage probability in down-comer piping is $2.25 \times 10^{-5}$ and breakage probability is $1.58 \times 10^{-9}$ at the end of 100 years.

Probabilistic Fracture Mechanics (PFM) model

PFM model developed by Harris et.al is used in this work. It considers cracks which get initiated during the operation of power plant because of IGSCC. The time of initiation and growth of IGSCC cracks is a function stress in pipe, material sensitization and chemistry of coolant flowing through pipe. Uncertainty in various random variables is modeling by probability density function. Failure in the pipe is checked by using net section collapse method. Leak probability and break probability in the pipe are evaluated. Inhouse code PIPEREL is used for this analysis. The PIPEREL CODE generates the pipe failure probability as a function of time by performing a series of deterministic lifetime calculations for different sets of inputs drawn from their respective statistical distributions. PIPEREL CODE makes use of Spherical Subset simulations for carrying out the iterations, which has got much faster converging capabilities over Crude Monte Carlo simulations.

IGSCC crack growth model

Following three conditions are necessary for IGSCC to occur:

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(a) Susceptible material (sensitization of stainless steel material);
(b) tensile stress (applied and residual);
(c) an environment that can provide the chemical driving force for the corrosion reaction.
Analysis concentrates on girth welds in the pipe and axial stresses are considered, since axial stresses have the major influence on crack growth in circumferential girth butt welds. Stress Corrosion Cracking (SCC) is modeled by considering it as a two-stage process, namely, crack initiation and crack propagation. The methodology used in this analysis for modeling SCC is described briefly in this section.

Crack size at initiation

The shape of the surface crack initiated due to SCC is considered to be semi-elliptical and the crack is oriented in circumferential plane. The length of initiated cracks is assumed to be log-normally distributed with a median value (50 percentile value) of 3.225 mm and standard deviation of log(b) as 0.85 Depth of the initiated crack is taken to be 0.0254mm.

Multiple cracks and Coalescence of cracks

In materials subjected to SCC, many cracks initiate successively and propagate simultaneously, and hence multiple cracks can be present in a given weld. The PRAISE model considered in this analysis is based on data from laboratory experiments on specimens about 50mm long [1-3]. This is taken into account by considering a given weld in the pipe to be composed of 50mm segments adding up to the length of the weld. Initiation time for each segment is assumed to be independent and identically distributed. The multiple cracks that may be present can coalesce as they grow. The linking of these cracks is done as per criteria given in ASME section XI.

Leak rates and detection

IGSCC cracks grow in size and may lead to leak or break in the piping. Crack which become through may or may not be of sufficient length to result in a complete pipe rupture. Leak detection instruments are mounted in the NPP for detection leaks in pipe. If leak rate is smaller than detection limit of these leak detection instruments, the crack can continue to grow, perhaps leading to a complete pipe rupture. If the leak rate is more than detectable limit plant can be shut down and leak piping can be repaired.

Failure Criteria

A net section collapse criterion is used for the failure analysis in this work. As per net section collapse criteria failure occurs because of the inability of the remaining cross section to transmit the applied loads. Critical value of stress is equal to the flow stress of material.

Spherical Subset simulations theory and application in this CODE

Evaluation of piping reliability involves solving multidimensional probability integral. Numerical integration methods cannot be used for solving this probability integral as they are computationally not efficient. Approximate methods like form and sorm are very difficult to apply because equation of failure surface is
Monte Carlo simulation is very popular and robust method, which is used for solving such probability integrals. The break probabilities of the NPP piping are of the order of 10^-8. To estimate this order failure probability number with error less than 10% at least simulations are needed. To perform these many simulations PC will take several days. This is because relatively large crack should exist to begin with for break to occur and probability of occurrence of large crack is very less. Since interest lies in calculating failure probability, simulation of cracks which do not lead to failure is in some sense wasted effort and consumes large computational time. Spherical subset simulation (S3) is method used for reliability problems of high dimension and have been shown to be robust and significantly more efficient than standard Monte Carlo simulations.

Subset simulation calculates the failure probability P(F) as a product of conditional probabilities based on a sequence of failure domains F1 ?F2?.....?FM, where the last element in the sequence is the target failure domain (FM = F)

In spherical subset simulation method whole failure domain (in standard normal space) is divided into several concentric hollow hyper-spheres. In the normal space, point in the probability space can be defined by its distance from the origin (i.e. radius) and angles made by radius vector with all axes. This angle measure follows uniform distribution and square of radius follows Chi-square distribution with degrees equal to number of random variables involved. Conditional failure probability within those strata is calculated using Monte Carlo method. Overall failure probability is calculated by summing up failure probabilities in all hollow hyper spheres. To further increase the efficiency of method random number are generated so that random numbers are uniformly distributed in given strata.

AHWR Down-comer Piping Reliability Analysis

AHWR is a 300 MWe, vertical, pressure tube type, boiling light water cooled, and heavy water moderated reactor. The reactor incorporates a number of passive safety features and is associated with a fuel cycle having reduced environmental impact. At the same time, the reactor possesses several features, which are likely to reduce its capital and operating costs. The AHWR is a land-based nuclear power station designed to produce 300 MWe power (gross). AHWR based plant can be operated in base load, as well as load following modes with a target life time load factor and availability factor of 80% and 90% respectively.

The reactor core is housed in calandria, a cylindrical stainless steel vessel containing heavy water, which acts as moderator and reflector. The calandria, located below ground level, contains vertical coolant channels in which the boiling light water coolant picks up heat from fuel assemblies suspended inside the pressure tubes of the coolant channel. The coolant circulation is by natural convection through tail pipes to steam drums, where steam is separated for operating the turbine to generate electricity from the coupled generator. Four steam drums, each catering to one-fourth of the core, receive feed water at stipulated temperature to provide optimum sub-cooling at reactor inlet.

The MHT system transports heat from fuel rods to steam drums using boiling light water as the coolant in the high pressure MHT system. The MHT system consists of a common circular reactor inlet header from which inlet feeders branch out to the fuel channels in the core. The outlets from the fuel channels are connected to tail pipes. The tail pipes carry steam-water mixture from the individual coolant channels to four steam drums. From each steam drum, four down-comers are connected to the inlet header.
Probabilistic fracture analysis of down-comer piping system reliability assessment is done. Leakage probability and breakage probability in the piping is evaluated. Uncertainties in crack length, sensitization of material, flow stress of material are considered. It is found that leakage probability in down-comer piping is $2.25 \times 10^{-5}$ and breakage probability is $1.58 \times 10^{-9}$ at the end of 100 years.

Demonstration
The most important research topic of the third period was demonstration at RWE Power Neurath. IZFP is the operator of the measurement devices. Together with MPA, RWE Power, VCE and WBI the time schedule was set up:

RWE
RWE continued the operation of the bypass as given above. The research teams of all WP 5 partners will be supported.

WBI
WBI analysed measurement data coming from the instrumentation of the bypass via IZFP. Together with IZFP WBI coordinated the tests. WBI analysed the modal measurement data delivered by IZFP.

MPA
The next step was participation in a measurement campaign with own measurements and also to finalize the Finite-Element-Model. These measurements should deliver experimental modal analyses and damping data for modal-updating. Challenges for model-updating were to idealize and to border the vibrating system since the bypass-system is coupled with other systems. These measures are part of an advanced SHM-System. To validate this advanced SHM-System, flaw simulations were planned such as an incorrect load carrying behaviour of struts or spring hangers, e.g. blocked hangers.

IZFP
IZFP was the operator of the measurement devices. Additional to that IZFP made its own experiments with guided waves at the bypass. The combination of modal analysis and guided wave analysis led to a SHM system for pipes.

ISC: Langasite sensors
ISC tested the new concept in the laboratory during the last period. Also for proofing of principle of the high temperature ultrasonic transducers demonstration activities are planned in summer 2011 at the bypass in the power plant Neurath.

CVS
For further study CVS made similar calculations:
- Same kind of analyses for additional set of bends: i.e. thick-walled main stream piping – 426x80, R=1700, including effect of different wall thickness per section;
- Include in consideration an additional loading factors: out-of-plane and torsion moments;
- perform a quantitative assessment for the creep life prediction utilizing a Robinson's rule (linear cumulative damage) or Kachanov/Robotnov damage theory
For the IRIS project the goal of this study is to develop a simple engineering approach that could be included in the conventional piping flexibility analysis. That will make possible the target oriented monitoring for piping working at elevated temperatures. Moreover, obtained results could be used for improving of existing standards.

6. Work Package 6 (Risk Paradigm)
Work performed
Since the beginning of Period 2, significant progress has been achieved in various directions towards the implementation of the Risk Paradigm, which is the main output of WP6. This progress refers to:
1. The development of the Risk Identification Methodology (RIM) and the Risk Inventory (RI).
2. The development of the Case Studies.
3. The development of the Risk Assessment Tool (RAT).
5. The development of the Risk Monitoring and Control System (RIMOCOS).

Concerning the expected development for the knowledge management of risk, progress was made towards the finalization of the Risk Core Ontology and the definition of the architecture and functionality of a Risk Knowledge Portal and the process is ready to enter the final stages of conclusion by developing the portal. Also, unplanned progress was made concerning the development of the Risk Management Standard for the European Industry (RMS) that was originally planned for development in Period 3.

In Period 3, significant progress has been achieved in various directions towards the finalization of the Risk Paradigm, which is the main output of WP6. This progress refers to:
1. Further enhancement of RAT by applying the algorithm that calculates risk through the integration of all the uncertainties (model parameters) in the risk parameter vector, namely $\lambda_f$, $\lambda_m$ and $\lambda_i$.
2. Further development and completion of the RIPREMIS by extrapolating from data the equations and boundary conditions that govern certain risk based decision-making problems.
3. Further development and completion of IRISRO by programming the core ontology and the domain-specific ontologies and their interrelations in relation with the IRISOW and IRISB case studies.
4. Development of IRISRIKPO.
5. Further development of the RMS through the process of CEN Workshop Agreement in the context of the IRIS projects.
6. Dissemination of the research results through publications and reports in the project’s context.
7. Demonstration of the final products to project partners and interested audience.

In the following sections, the overall progress achieved during Period 3 concerning the abovementioned activities is presented in details. Accomplishment of these activities delivers 100% of the IRIS Risk Paradigm and fulfills the respective goals set in the context of the IRIS project.

Development of the Case Studies
The IRIS Risk Paradigm tools and methods developed during period 2 were tested in case studies that were developed for fine-tuning and validation reasons. Therefore, progress and advances in the RAT and RIPREMIS tools is presented directly via the results of the IRISOW, IRISB and IRISTP case studies. It is necessary to highlight that the IRISTP case study was developed with the synergy of WP4 as validation and demonstration example of the applicability of the IRIS Risk Paradigm to other industries (i.e. environmental). The overall progress with regard to this outcome is presented in the following subsections.

Progress of the IRISOW Case Study
The performance of the Offshore Wind Turbine that has been used as a model case for the development of the IRIS Risk Paradigm has been described in terms of joint displacements, as well as in terms of member stress ratios. These stress ratios correspond to: (a) overall strength stress ratio (SRs) in all tubular members and (b) stress ratio due to local buckling in conical transitions members (SRc). The SRs is defined as the maximum value among the stress ratio due to combined axial compression and bending and the stress ratio due to combined axial tension and bending. The SRc is defined as the stress ratio due to axial compression and bending in the case of conical transitions members. In the case of pile members, the stress ratio due to column buckling (SRp) is taken into account. Taking advantage of the symmetry of the OWT and its loading to reduce the required response variables needed to be monitored, 27 performance quantities are considered (members, joints and segments).

Progress of the IRISB Case Study

The application of the IRIS Risk Paradigm to the IRISB case study has been further extended, in order to achieve a continuous updating of risk assessment based on real-time monitoring data. This is accomplished through a combination from data received from a monitoring system that could apply the RIMOCOS principles and the implementation of Bayes Theorem. A representation example that simulates such an application is following below.

The examples refer to the effect of strength degradation due to corrosion on the loading level of the mooring chains of a cable-moored array of floating breakwaters. This array of floating breakwaters consists of three identical floating breakwaters connected with hinges and is held in place by means of six mooring chains, where four of them form an angle of 45° with respect to the x axis on the x-y plane and the rest of them are perpendicular to the x axis on the x-y. This example focuses on the posterior assessment of time-evolved risk.

In order to achieve the posterior assessment of risk, it is necessary to calculate the posterior time-variation of maximum loading and strength for two cases of monitoring data, K1 and K2, considering prior knowledge and real-time monitoring data. In more detail, both maximum loading $\max T_{tot}$ and $T_{break}$ are considered time-variant. Time-variant $\max T_{tot}$ and $T_{break}$ according to posterior knowledge is calculated after applying Bayes Theorem.

Application to the new Case Study: The Żelazny Most tailing dam

The IRIS ris paradigm methodology has been applied to the Żelazny Most tailing pond, a dam constructed to deposit the contaminated wastes produced by the three copper mines in South-West Poland.

Description of the Żelazny most tailing DAM

KGHM Polska Miedź S.A. is a state-owned mining company created in 1961. The mining activity of KGHM is focused at three copper mines, the Lubin, the Rudna and the Polkowice- Sierszowice mine, all three located in Lower Silesian Voivodeship (province).

The separation of the copper minerals from the rest of the ore is performed at the mill using the flotation method. According to KGHM’s website (KGHM website, 2011), about 4 – 6 % of the weight of the extracted ore is copper. The great majority of the extracted material is waste, called tailings, that contains heavy metals and other contaminants; since no large-scale application for the tailings has been found so far, the waste has to be safely deposited at the ground surface. That purpose for the waste of the three KGHM mines is served by the Żelazny Most tailing pond.

The tailing dam is constructed according to the upstream method; a starter dam is constructed and after then the tailings are discharged in the periphery of the structure using spigots or cyclones. As the tailing slurry is released, the coarser materials settle quickly forming the new perimeter dike and the wide beach area while the finer material moves along the beach to the pond. Each new perimeter dike is founded on
the currently existing dam beach. So, the height of the dam is continuously increasing while the dam’s district remains the same throughout the structure’s life. Part of the clarified water of the tailing pond is send back into the mill.
The Želazny Most tailing dam started operating in 1977 (KGHM website, 2011). Since then, it receives approximately 80,000 tonnes of tailings in liquid form per day, causing its height to increase by about 1.25-1.50m per year (Jamiolkowski et al., 2010). At its current state the dam’s periphery has a length of 14.3km and the area occupied by the structure is about 13.94 km² (KGHM website, 2011). Jamiolkowski et al. (2010) state that the dam’s crest is around 170m above sea level and that it is 22-60m poked out from the ground natural terrain, forming the largest tailing dam in Europe. If the height increase rate remains constant until exhaustion of the ore body (in 2042 according to Jamiolkowski et al., 2010), then its height will exceed the 100m at its lowest level.
The tailing dam is a key feature of the mining process because an incapacity of the dam to receive the waste will result to an abrupt stoppage of the whole mining activity, with great economical consequences for KGHM. At the same time, a failure of the tailing dam can cause huge environmental problems and jeopardise the health of the nearby town population.
There are no published works about the Želazny Most dam safety other than the one by Batog et al. (2009) and Jamiolkowski, 2010. The first authors assess the eastern dam’s section stability in respect to the water level variation and then they determine the deformation process. Their results are in good agreement with field measurements. The latter present the major geotechnical problems encountered in the Želazny Most tailing pond deterministically. The flow failure risk is considered low while inclinometers are installed to monitor the displacements at the North and the East section of the dam.
Studies about the environmental consequences of the Želazny Most tailing dam under normal conditions are also rare. Yu-Zhuang Sun (1999) estimates the pollution potential of the Odra river due to the presence of the Želazny Most tailing pond based on the results in 15 samples taken from the dam and the nearby streams. Also, Robert Duda (2004) uses a 2d hydrological model to assess the migration of contaminants from the pond and the beaches to the dam bedrock and then into the foreground under working conditions. It should be noted that no publications about the
The present study concerns the risk assessment of the Želazny Most tailing pond in respect to slope instability. The risk is expressed in terms of the area that will be contaminated by the released slurry once slope failure occurs.
Development of the IRIS RISK PORTAL (IRISRIKPO)
The development of the Risk portal is based on the specifications set by [3]. The portal supports risk case management and querying capabilities, allowing the Risk Engineer and end-user to consult the system in order to look for risk cases similar to his/her own current risk project. Furthermore, as a proof of concept, an on-line risk assessment tool has been implemented and connected to the IRIS Risk Portal as a Web service, in order to be able to provide on-line risk consultation for the Offshore Wind Turbines case study. The portal uses state-of-the-art Web application development frameworks and Semantic Web technologies, and it is accessible from http://irisportal.csd.auth.gr.
The Risk Ontology
The risk case knowledge is represented in terms of an OWL 2 ontology [5] that is a revision of a previous risk ontology (which was in the OWL 1 language). The revision was necessary in order to reduce the complexity of the initial ontology, a factor that affects the reasoning and querying performance. This requirement is very important, since there is a need for online (real-time) reasoning and querying tasks in order for the portal to be able to respond fast and to provide consistent results to users.
The representation of the terms, relationships and restrictions of the domain e.g. case studies, risk cases, risk variables and their relationships, is based on 28 classes and 32 properties.

Summary of the Significant Results during Period 2

The most significant from the results during Period 2 are as follows:

1. Definition and development of two case studies, namely the IRIS Offshore Wind Turbine (IRISOW) and the IRIS Bridge (IRISB) that constitute the modeling of real cases to facilitate the development of the Risk Paradigm's constituent elements (sub-products). In both cases, co-operations with IRIS partners were established and successfully carried out. The IRISOW case study is disseminated through conference presentations and publications in conference proceedings, while the IRISB case study is disseminated through the IRIS project's dissemination activities (Summer Academy) and published in project reports.

2. Development of the Risk Identification Methodology (RIM) sub-product and application to the two case studies for the modeling of specific risk assessment problems. The results are disseminated through the IRIS project's dissemination activities (Summer Academy and WPs meetings) and published in project reports.

3. Development of Risk Inventories (RI) with respect to RIM and the two case studies that defined specific risk assessment problems. The results are disseminated through the IRIS project's dissemination activities (Summer Academy and WPs meetings) and published in project reports.

4. Development of the Risk Assessment Tool (RAT) by providing the modeling approach and a mathematical proof for its conformity with existing risk assessment approaches. RAT is modeled partially and tested for validity in the IRISOW case study and another example, while the description with regard to the modeling of the rest of the parameters has been also clarified and demonstrated through a specific example. All results are disseminated through conference presentations and publications in conference proceedings.

5. Development of the Risk Prevention and Mitigation Strategy (RIPREMIS) sub-product by proposing a methodology for risk based decision making and selection between different risk response strategies. The methodology was initially tested for validity in the IRISOW case study. A more focused approach both in terms of application field (technical risks) and decision making alternatives (maintenance schedules) was applied in another example to couple existing approaches with the risk assessment approach proposed in the context of the IRIS Risk Paradigm. All results are disseminated through conference presentations and publications in conference proceedings.

6. Review and comparative analysis between monitoring technologies applied in the construction industry towards the identification of the most appropriate tools for the development of the Risk Monitoring and Control System (RIMOCOS). Demonstration of the initial conclusions with a specific example that involves a visio-based tracking method.

7. Registration in the CEN Workshop Agreement that shall collectively standardize the IRIS project's results. Through this process, the development of the Risk Management Standard for the European Industry is anticipated.

8. Further development of the architecture of the ontology server with respect to the RIM sub-product. The results are disseminated through the IRIS project's dissemination activities (Summer Academy) and published in project reports.

9. Update of the risk glossary.

The most significant from the results during Period 3 are as follows:
1. Definition and development of the IRISTP case study.
2. Full application of the Risk Assessment Tool (RAT) to the IRISOW and IRISTP case studies and further refinement of the algorithmic method. Numerical examples have been worked out in both case studies, while the compatibility of the method has been proven and demonstrated through the use of newly developed and already existing software tools.
3. Further development of the Risk Prevention and Mitigation Strategy (RIPREMIS) sub-product by refining the numerical tools through real data. The applicability of the method was tested in the IRISOW case study and another example and risk-based decision-making was incorporated to the IRIS Risk Paradigm process.
4. Full development of the IRIS Risk Portal as a Web service that integrates state-of-the-art Web application development frameworks and Semantic Web technologies, in order to support risk case management in different contexts. The portal was developed to allow querying capabilities for the Risk Engineer and the end-user to consult the system and retrieve similarities in risk cases similar to the one in hand. It, also, integrated RAT to provide on-line risk consultation.
5. Participation in the CEN Workshop Agreement that shall collectively standardize the IRIS project’s results.
6. The whole risk management process that constitutes the IRIS Risk Paradigm was developed and validated through specific diverse industries case studies. Tools and methods were developed and integrated to form a new risk management platform. The IRIS Risk Paradigm was completed to constitute a shift in managing risks.

7. Work Package 7 (Online Monitoring)
Following the degradation concept developed in work package 3 (WP3) and the input from the other industries it became necessary to develop a methodology for the determination of fragilities using monitoring results. Various contributions from the Consortium have been received and utilized for this purpose.

INTRODUCTION

Europe is experiencing an increasing number and impact of disasters due to natural hazards and technological accidents caused by a combination of changes in its physical, technological and human/social systems.

Industrial accidents triggered by natural events, such as e.g. earthquakes, floods, lightning etc., are referred to as “Natech” accidents. Natech accidents have occurred in relation to natural hazards and disasters and have resulted in the release of hazardous substances leading to fatalities, injuries, environmental pollution and economic losses (Krausmann et al., 2011). One of the principal problems of most Natech accidents is the simultaneous occurrence of a natural disaster and a technological accident, both of which require simultaneous response efforts in a situation in which lifelines needed for disaster mitigation are likely to be unavailable. The catastrophic events in March 2011 in Japan have demonstrated this case. Natech risk differs from technological or natural risk as its multi-hazard nature requires an integrated approach to risk management.

GIS and related technologies can be used for monitoring and responding to disasters, as well as for planning community rebuilding or even for relocation in extreme cases. Meanwhile natural disaster GeoInformation Systems (GIS) have been implemented in nearly all European countries, however, still with different standards and definitions, terminology, data bases and details, in spite of the ongoing
European INSPIRE activities. Therefore the compatibility of data and information is one of the major problems. The consideration of property rights of data is another obstacle for the international use and data exchange.

The assessment of potential natural hazards is fundamental for planning purposes and disaster preparedness, especially with regard to supervision and maintenance of industrial facilities and of extended lifelines. Hence it is imperative to identify those areas most susceptible to different types of natural hazards as earthquakes, landslides, flooding, tsunamis or storms. Earthquake hazard zonation is the first and most important step towards a seismic risk analysis and mitigation strategy. Therefore, it is clearly crucial to identify the areas most vulnerable to earthquake occurrence, where the adoption of mitigation measurements is more urgent.

EARTHQUAKES
As a prerequisite for earthquake preparedness a detailed inventory of sites more susceptible to earthquake damage and to earthquake related secondary effects due to local site conditions has to be carried out (Yong et al, 2008). The variability in earthquake-induced damage is mainly determined by the local lithological properties, thickness of the soil and lithologic unit layer, by hydrogeological and by geomorphological conditions. It has been observed that at many sites surface motions are influenced primarily by top 20-30 m of the sub-surface. These conditions, intern influence the amplitude, the frequency and duration of ground motion at a site.

Local Site Conditions
Whenever a near-by, stronger earthquake happens, damage intensity might vary within the same distance from the earthquake epicentre due to the influence of local site conditions. Local site conditions play an important role when considering earthquake shaking and damage intensities and their local variations: The ground-shaking during an earthquake predominantly depends on factors such as the magnitude, properties of fault plane solutions, the distance from the fault and local geologic conditions. The most intense shaking experienced during earthquakes generally occurs near the rupturing fault area, and decreases with distance away from the fault. Within a single earthquake event, however, the shaking at one site can easily be stronger than at another site, even when their distance from the ruptured fault is the same.

Groundwater level variations and associated saturation changes in sand layers within near-surface aquifers can influence local response spectra of the ground motion, through modification of shear-wave velocity (Hannich et al., 2006). Changes of the groundwater level can also have a considerable influence upon the liquefaction potential of a region due to in-situ pore-water pressure responses in aquifers during earthquakes triggering mechanism of liquefaction. Liquefaction that affects the human-built environments is mostly limited to the upper 15 meters of soil.

Estimation of the degree of local seismic wave amplification (site effects) requires precise information about the local site conditions. In many regions of the world, local geologic information is either sparse or is not readily available.

In order to further reduce the impact of earthquakes, it will also be crucial to fill the gaps between seismic micro-zonation, macroseismic observations, seismotectonic research and building codes to secure improved safety for buildings. Further on, information of long-term information of geodynamic processes (uplift, subsidence, horizontal movements) are a basic need for the safety of cities, settlements, infrastructure and industrial facilities.
METHODS

A prerequisite for emergency preparedness is the collection, georeferencing and storage of available maps and data in a GIS environment in order to get a reference data base. Spatial data layers come from various sources such as topographic maps and thematic maps (soil maps, geologic and hydrogeologic maps, land use etc.) and field survey. Past hazards have to be included into the data base such as landslides or flooding events.

Earthquake data of different international geophysical institutions and surveys were gathered from European countries and stored into the GIS databank. Macroseismic maps gathering local observations during earthquakes were evaluated. GIS integrated remote sensing data and geodata analysis were used to visualize factors related to the occurrence of higher earthquake shock and / or earthquake induced secondary effects: factors such as lithology (loose, unconsolidated sedimentary covers) in basins and valleys linked with higher groundwater tables, faults, or steeper slopes (susceptible to landslides).

Evaluations of Digital Elevation Model Data (DEM)

To automatically identify the landform types that affect site conditions, the relief elements were grouped into terrain features. Terrain features were described and categorized into simple topographic relief elements or units by parameterizing DEMs such as height levels, slope gradients, and terrain curvature.

From SRTM and ASTER DEM (Digital Elevation Model) data derived morphometric maps (slope gradient maps, drainage, etc.) were combined with lithologic and seisomotectonic information in a GIS data base (Theilen-Willige and Wenzel, 2009, Theilen-Willige, 2010).

When searching for areas susceptible to soil amplification, liquefaction or compaction the so called causative or preparatory factors have to be taken into account. Some of the causal factors can be determined systematically: From slope gradient maps are extracted those areas with the steepest slopes, and from curvature maps the areas with the highest curvature as these are more susceptible to landslides. Height level maps help to search for topographic depressions covered of almost recently formed sediments, which are usually linked with higher groundwater tables. In case of stronger earthquakes those areas often show the highest earthquake damage intensities. From ASTER DEM data of the investigation areas the flat areas with no curvatures of the terrain and low to no slope gradients and the lowest areas are extracted. From geologic and hydro-geologic maps the youngest, unconsolidated sediments are mapped and converted to ESRI-Grid-format as higher earthquake damages have been documented related to these sediments.

An important step towards susceptibility mapping is the weighted overlay method in ArcGIS as the influence of the factors on earthquake ground motion is not equally important in the analysis. According to the local specific conditions and, thus, varying influence these factors are weightened (in %). The percentage of influence of one factor might be changing, for example due to seasonal and climatic reasons, or distance to the earthquake source. As a stronger earthquake during a wet season will probably cause more secondary effects than during a dry season, the percentage of its influence has to be adapted. In very hot and dry seasons the risk of liquefaction or landslides is generally lower than in spring times. The sum over all causal factors / layers that can be included into GIS provides some information of the susceptibility to amplify seismic signals. After weightening (in %) the factors according to their probable influence on ground shaking, susceptibility maps were elaborated, where those areas were considered as being more susceptible to higher earthquake shock intensities, where “negative” factors occur aggregated. Whenever an earthquake happens in these areas, now it can be derived better where the
“islands” of higher ground shaking are most likely to occur by adding the specific information of the earthquake to the susceptibility map approach.

Of course further data have to be included whenever available, such as movements along active faults, focal planes, uplift / subsidence, 3D structure, lithologic properties and thickness of lithologic units, shear wave velocities, etc.. The analysis method and integration rules can easily be modified in the GIS architecture as soon as additional information becomes available.

The weighted overlay approach can be used as well for the detection of areas prone to tsunami flooding. This is demonstrated by the example of NE-Japan.

When comparing the weighted overlay map showing the susceptibility to flooding in NE-Japan with the flooded areas after the 11.March 2011 earthquake and tsunami there is a clearly visible coincidence in the coastal areas of the calculated higher susceptibility to tsunami flooding (dark-blue) and the flooded area after the tsunami as visible on the MODIS image (14.3.2011).

Digital Image Processing of LANDSAT, RapidEye- and IKONOS-Satellite Data
RapidEye-, IKONOS- and LANDSAT-data were used as a further basic layer in the earthquake GIS, such as for the elaboration of actual land use maps. Some data layers, such as land use and forests, are dynamic in nature and need to be updated frequently. For disaster preparedness the almost detailed detection and documentation of settlements, infrastructure, industrial facilities, etc., that might be exposed to earthquake and other hazards, especially their different exposures to soil amplification, landslides or active tectonic processes is necessary.

Based on RapidEye satellite data different RGB combinations of the different bands were tested. Low pass and high pass filters and directional variations were used for the detection of subtle surface structures such as meanders or landslides. Merging the image products derived from “Morphologic Convolution” image processing in ENVI software with RGB imageries, the evaluation feasibilities were improved. Vegetation Index (NDVI)-imageries were used to detect linear anomalies that might be related to subsurface structures. Unsupervised and supervised image classifications based on LANDSAT-, RapidEye- and IKONOS-data served as base for land use mapping such as forests, wetlands, fields and infrastructure.

Change detection tools help to detect environmental changes such as changes of land use or infrastructure. Environmental and infrastructural changes have to be considered when dealing with emergency planning. Roads exposed to flooding or land-slides have to be known and in case of emergency alternative routes to be arranged. Change detection tools become most important after the occurrence of disasters. The comparison of pre- and post-disaster imageries contributes to the documentation of damages. This was carried out in the case of the sludge spill disaster in Hungary.

Traces of Neotectonic Movements – Lineament Analysis
Earthquake preparedness comprises knowledge of the tectonic pattern as surface-near fault zones can influence in case of stronger earthquakes not only the susceptibility to landslides, to liquefaction or ground motion intensity, but also to horizontal and vertical movements. An excellent indicator of surficial lithologies, geological structures and ongoing morphotectonic processes is the drainage pattern. Neotectonic movements can be detected due to linear anomalies in the drainage pattern. These linear anomalies are mapped as lineaments.

EVALUATIONS OF SATELLITE DATA
Evaluations of SRTM-, ASTER-, IKONOS- and Shear Wave Velocity Data
In order to provide a first-approximation of local geotechnical site conditions, an approach was developed to characterize potential ground motions on the basis of known correlations between variations in shear-wave velocity and topographically distinctive landforms by applying geomorphometry, a quantitative description of landforms based on DEMs (Allen and Wald, 2007, Yong et al., 2008). Wald and Allen (2007) described a methodology for deriving maps of seismic site conditions using topographic slope as a proxy. Vs30-measurements (the average shear-velocity down to 30 m) are correlated against topographic slope. They also compared topographic slope-based Vs30 maps to existing site condition maps based on geology and observed Vs30 measurements, where they were available, and found favorable results. To get a first impression of areas in where Vs30-values are estimated to be lower and, thus, might contribute to higher earthquake damage, the assumed Vs30-data provided by USGS were used in several investigation areas such as in the Vienna area or Central Hungary. A distinct correlation between areas covered by unconsolidated, Quaternary sediments and the by this approach derived lower Vs30 values (< 200 m/sec) can be observed. When combining the weighted overlay results with the estimated shear wave velocities there is a clearly visible coincidence of areas with assumed Vs30 < 200 m / sec and areas with higher susceptibility to soil amplification due to local site conditions. As example the result of the weighted overlay calculation is shown from the area of Szekszard in Tolna, Hungary. In the dark-red areas earthquake shock intensity can be assumed to be higher because of summarizing effects of site properties (such as lowest areas, higher groundwater tables, sedimentary covers). Making use of attenuation relations of ground motion parameters and of geological information contributes to the elaboration of damage scenarios, even when the input parameters regarding earthquake source, propagation medium and site characteristics are roughly estimated. Assuming a near-field earthquake with a magnitude Ml > 5, the results of the attenuation calculations of seismic waves could be merged with the weighted-overlay results in order to get an idea, where the earthquake shock might be stronger due to local site conditions (provided that the susceptibility to soil amplification is higher, where “negative” factors occur aggregated). The method described in the present study aiming at the elaboration of a database and the detecting local site conditions which influence earthquake events, could become in the future part of a comprehensive disaster management system. For disaster preparedness the almost detailed detection and documentation of settlements, infrastructure, industrial facilities, etc. that might be exposed to earthquake and other hazards, especially their different exposures to soil amplification, landslides or active tectonic processes is necessary. Another important point is the GIS integration of disaster involved institutions such as fire brigades, police stations, hospitals and disaster management centres. Thus, strategic databases were created: Data for hospitals and health centres, schools, kindergartens, governmental buildings, police, fire stations, industrial buildings, gas stations and infrastructure data, provided by the Disaster Management Directorate of Tolna County in Szekszard, were collected and stored as shapefiles in the GeoInformation System. Information of the capacities of hospitals (staff, beds), fire brigades and police stations (staff, equipment) were included as well as population data. Data and maps providing information of functions of buildings, especially of industrial areas, were added. The processing of multi-sourced data, the information of the public and the extraction of information and effective visualisation are major tasks. Information of the public via Youtube, Twitter or Facebook can be gathered in case of emergency and integrated into the existing GIS. When integrating infrastructural and land use data into the GIS data base it can now derived better where
the damage after a catastrophic earthquake could probably be higher. In case of emergency rescue teams might be send first to those places situated in areas with probably higher susceptibility to earthquake shock and earthquake related secondary effects.

However, the amount of local damage will be determined by the specific earthquake parameters such as depth, magnitude and orientation of the fault plane solution, varied by the specific geologic conditions and the situation of the buildings (construction material, floors, age, etc.).

Another example is shown from the city of Vienna. The results of the weighted overlay calculations based on ASTER DEM and geologic data were converted from ESRI-Grid-data format into shapefile-format and, then, intersected with infrastructural data. When merging for example shapefiles of industrial / commercial facilities with the shapefiles of weighted-overlay derived higher susceptibility to soil amplification-grades, it can be visualized which facilities are situated in areas with aggregated causal factors.

MONITORING OF NATECH-EVENTS

Fast data acquisition and extraction of relevant information on the extent and impact of earthquakes and related damages are important issues for mapping civil catastrophes today (Hoja et al., 2010). On October 4th, 2010, an accident occurred at the Ajkai Timföldgyár alumina (aluminum oxide) plant in NW-Hungary. A corner wall of a waste-retaining tailing dam broke, releasing a torrent of toxic red sludge down a local stream. Several nearby towns were inundated, including Kolontar and Devecser, where the sludge was up to 2 meters deep (ZKI, 2010). The pre- and post-disaster situation is documented by RapidEye-imageries. Although in this case no earthquake was documented the days before the wall collapse by the geophysical surveys in the surrounding countries, a considerable number of smaller to medium earthquakes up to magnitudes Ml 3 happened in the last years within a radius of approximately 30 km around the plant. Most of them occurred in depth between 5-10 km. It cannot be excluded that these events had a certain influence on the wall stability. As the area of Ajka is situated within a transition zone between positive (uplift) and negative (subsidence) vertical movements, besides being compressed and moved towards east with velocities of about 1,3 mm / year (Fodor et al., 2005, Bus et al., 2009), these almost aseismic movements might have played a role, too, besides the wet seasons before the accident.

Disaster preparedness in the area of tailing dams should consider the geomorphologic setting. The necessary information can be derived among others by the evaluation of free available Digital Elevation Models (DEM) such as provided by the Shuttle Radar Topography Mission (SRTM) and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) Global DEM. When comparing the susceptibility to flooding-map of the plant area, calculated based on the weighted overlay-approach summarizing causal factors ([slope < 15°]+ [height level < 190 m] +[minimum curvature>190]), with the mud flow distribution in October 2010, the coincidence of the predictable path and the mudflow path after the accident is evident. The mudflow took exactly the path as assumed according to the height level and geomorphologic situation.

CONCLUSIONS

Remote sensing and GIS form an essential tool for getting actual infrastructural information as reference base for emergency planning. Fast data acquisition and extraction of relevant information on the extent and impact of earthquakes and related damages are important issues for mapping civil catastrophes today. Change detection tools become most important after the occurrence of disasters. The comparison of pre- and post-disaster imageries contributes to the documentation of damages.

A typical monitoring campaign has a well proven structure. The activities in the individual elements are:
• Metadata: all available information about the object is collected, sorted and as far as possible electronically stored in the knowledge base. A metadata format is available
• Campaign Planning: ideally the proportions of the structure are already available in the database (if possible imported as .dwg). The layout creator loads the geometry and provides an automatic proposal for a sensor layout. Sensors are selected from the database and forms for onsite records are printed
• Monitoring: the designed monitoring system will be used, the actual location of the sensors recorded and the respective channel layout confirmed. The raw data are transferred to the database
• Database: it contains all previous and actual information. It also holds the records of all previous campaigns for comparison
• Routine Assessment: all the various assessment routines are automatically run on the incoming data. Results are automatically transferred back to the database
• Previous Data: a check whether previous data are available in the database is performed in order to decide on the next steps. The extension to the 4th dimension (time) is performed
• Comparison: in case that previous data are available comparison routines look after eventual changes in the character and results
• Case Based Reasoning: in case that no data are available the closest related case will be selected for comparison. Results to be expected will be provided. A 1st point on an eventual baseline with respective uncertainties is given
• Plausibility Check: various options for plausibility checks are tried and proposed to the engineer. The results are ranked in order to reduce the necessary engineering input
• Damage Detection: 2 levels of damage detection are concentrated here. First of all it shall be found out whether damage is present or not. It can be either a trend in the baseline or a phenomenon from the various assessment routines (i.e. VCLife) that are used. At the same step damage is quantified. This means with the allocation on the baseline the eventual consumption of lifetime through damage is quantified

• Damage Location: in case that a sufficient number of locations have been recorded a location routine becomes feasible. It computes the most probable location of a damage by assessing Eigenmodes and statistical pattern distributions
• Remaining Lifetime: when a baseline has been firmly established the remaining lifetime can be calculated by extrapolation. The quality of the result is depending on the length of the timeline where data are available
• Recommendations: the results of the damage detection routines end in recommendations which are given as immediate, short time, long term or permanent actions. This output satisfies the requirements of the standard
• Reporting: an automatic report is generated consisting of an executive summary (maximum 1 page) which concludes all the findings, provides the risk rating and lists the recommendations. As an annex the detail information is provided as specified by the client
• Submission to Users: the automatic report will be checked by an engineer prior submission in order to avoid misunderstanding. Depending on the nature of the structures monitored this expert assessment is more or less elaborative

Practice has shown that civil engineering produces a variety of prototypes of structures. This makes these campaigns particularly difficult. The number of repetitions is small and actual comparisons with close results are rare. This implies that the engineering aspect and expert interference will remain in this
procedure most probably forever. Nevertheless there have been hopeful results in assessment on element level (i.e. torsional bracings or lighting poles) where already 99.5% of the cases have been correctly rated as long there are no specific defects in the structure. The rating of structures with small defects showed and efficiency around 70%. On local and global level of a structure an estimated efficiency of 50% is targeted.

Significant Results
Many significant results have been achieved in Period 2 and 3:
- The experimental fragility update and assessment procedure is unique. It goes far beyond of American or Asian activities and even beyond other European programs.
- The underlaying IT-concept developed by IRIS has been accepted and taken over by other projects and activities on large scale. Particularly the large U.S. NEES-program has changed its strategy.
- The lifecycle procedure developed has received major attention because of its practicality and link to quantities received from monitoring. This is a decisive step forward.

These results have been tried out particularly at the international bridge test in New Jersey where a global audience is able to watch the superior European approach.

Further consolidations of the activities had the highest priority in Period 3. Only minor development steps were open which were be fully achieved. The focus of the work in Period 3 was on demonstration (particularly the large demonstration in Hungary in May 2011) The focus was further shifted from theoretical development into feasible frameworks for all industries. There was a major consolidation effort during the Summer Academy 2011 in September. At this occasion a last harmonization and adjustment effort was taken.

A major effort was devoted to dissemination of the results.

8 Work Package 8 (Risk Informed Design)
The organizational issues like data repository, exchange platform, database and web representations have been completed in the previous period already. The works to create IT-tools are permanently going. The concentration in the respective period therefore had to be on Standardization which has been identified as a major factor for exploitation.

Work performed in the Period
The Knowledge Base
The work for the harmonized degradation model has been put in front of the activities. Parallel to the theoretical development practical demonstration tools based on MS Excel have been prepared (LCC Demo in various dissemination events). This has been proven extremely effective. A huge demand for information has been found. For details of the technology refer to WD-220.

Significant Results
Among the many IRIS results 2 are most significant:
- The generic IRIS degradation model (WD-220)
- The generic IRIS risk-paradigm (WD-172, 289)

Both are overarching results covering many detailed development steps. The management of the constructed infrastructure requires models that describe the entire lifecycle. Such a model of generic nature has been proposed and formulated in WD-220. It is based on experience, theoretical elaboration and a detailed literature review. The basis of development has been the experience with bridge
management where sufficient data are available to calibrate the theoretical approach. This generic model can be applied directly for bridges and with minor modifications to any other structure, or even systems towards the system of systems.

Conventional lifecycle models are based on the information provided by the undelaying databases. In order to introduce objective values for assessment a tailor-made model had to be developed, which utilises state of the art information from literature (on global scale) as well as the experience gained in the demonstration cases performed in IRIS. These destructive tests enabled to monitor the entire lifecycle by scaling time.

Current practices in risk assessment and management for our infrastructure are characterized by methodical diversity and fragmented approaches. In retrospect these risk and safety paradigms resulted from diverse industries driven and limited by available knowledge and technologies. The IRIS developers recognized their obligation to reconsider risk and safety policies, having a more competitive industry and more risk informed and innovation accepting society in mind. The new IRIS risk paradigm is of generic nature enabling application in any industry and situation. A graphic representation as promoted by IRIS is given.

The third period was devoted mainly to the elaboration of dissemination material on the results achieved. Furthermore the started standardization process was conducted.

Potential Impact:
Use of foreground and dissemination activities

IRIS is an industrial research project where the uses of foreground and dissemination activities are handled with the highest priority. The plan was focused on the following key activities:

• Continuation of the development and publication of the result in 2 textbooks published by a reputed publisher
• Major demonstrations where all interested parties are welcome to participate
• Conferences and symposia where papers are published, presentations are held and the technology is demonstrated in a booth life and on-line (IABMAS and IABSE 2010)
• Training of interested user groups in house, in case the user is potential enough, or in well organized tutorials which are attached to the projects major events
• The events organized by the project are opened to experts and users from outside which are invited to participate, join the discussion and provide contributions to the future planning and conception
• Active maintenance of the project website with focus on dissemination, also providing access to data and information which is already suitable for public use

A list of dissemination events is compiled below showing the size of the audience reached. The activities undertaken are actually many more than anticipated. This is based on the experience that it requires reasonable time to prepare such events and experience should be gained to perform well when the results are available. Then they should reach their targets. It can be also seen as a training of the dissemination abilities and a market study for the anticipated products.

Period 1 (MoM # - Venue - Type – Audience reached)
051 13.10.08 Beijing, China 14. WCEE (World Congress on Earthquake Engineering) 3380
107 15.05.09 VDI Baudynamic Kassel, Germany Special Symposium on Structural Dynamics 122
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>116 02.06.09</td>
<td>Stuttgart, Germany iNTeg-Risk Conference 250</td>
</tr>
<tr>
<td>127 08. - 10.06.09</td>
<td>Hohenkammer, Germany GEM Outreach Meeting (Global Earthquake Model), PPP Project 110</td>
</tr>
<tr>
<td>138 22.07.09</td>
<td>ETH Zurich, Switzerland 5. SHMII Conference (Structural Health monitoring and Intelligent Infrastructure 145</td>
</tr>
<tr>
<td>157 04.09.09</td>
<td>Summer Academy, Zell/See IRIS event, Tutorial and Summer Academy 81</td>
</tr>
<tr>
<td>161 09.09.09</td>
<td>Stanford 7. IWSTM (International Workshop on Structural Health Monitoring) 550</td>
</tr>
<tr>
<td>167 20.09.09</td>
<td>Sofitel Paris 7. CDWS (International Cable Dynamics Workshop) 88</td>
</tr>
<tr>
<td>171 22.09.09</td>
<td>Puerto de la Cruz, Spain MAS 2009 (International Modelling and Simulation Conference) 370</td>
</tr>
</tbody>
</table>

**Period 2 (MoM # - Venue - Type - Audience reached)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>201 06.10.2009</td>
<td>Mageba, Bülach, Switzerland IRIS Dissemination Meeting 24</td>
</tr>
<tr>
<td>205 21. - 22.10.2009</td>
<td>Pafos, Cyprus 16th Greek Construction Congress 920</td>
</tr>
<tr>
<td>212 09.11.2009</td>
<td>Geneva, Switzerland IMS-meeting 200</td>
</tr>
<tr>
<td>225 29.11.2009</td>
<td>Guangzhou China International Symposium on Innovation &amp; Sustainability of Structures in Civil Engineering 2009 (ISISS) 800</td>
</tr>
<tr>
<td>228 09. - 11.12.2009</td>
<td>Lucca, Italy DETAILS Workshop 56</td>
</tr>
<tr>
<td>232 17.12.2009</td>
<td>Autostrade del Brennero, Trento, Italy IRIS Dissemination 14</td>
</tr>
<tr>
<td>244 25.01.2010</td>
<td>Leer, Germany Cooperation with Wind Energy Industry 6</td>
</tr>
<tr>
<td>251 02.03.2010</td>
<td>BAM, Berlin, Germany Monitoring Seminar 25</td>
</tr>
<tr>
<td>253 04.03. 2010, Purdue University NEES-EC Collaboration 42</td>
<td></td>
</tr>
<tr>
<td>269 15.04. 2010, HCMC, VEC, Vietnam IRIS Demo 247</td>
<td></td>
</tr>
<tr>
<td>282 20.10.2009</td>
<td>Hong Kong, SAR International Conference on Adaptive Structures and Technologies (ICAST’09) 321</td>
</tr>
<tr>
<td>291 08.03.2010</td>
<td>San Diego, California SPIE Smart Structures/NDE 2010 4100</td>
</tr>
<tr>
<td>321 15.06.2010</td>
<td>Haus der Wirtschaft, Stuttgart, Germany iNTeg-Risk Conference 120</td>
</tr>
<tr>
<td>329 21. - 22.06.2010</td>
<td>New Jersey 202 Bridge International Demonstration 660</td>
</tr>
<tr>
<td>347 12.07.2010</td>
<td>IABMAS, Philadelphia, U.S.A. IABMAS Conference 697</td>
</tr>
<tr>
<td>388 30.08.-03.09.2010</td>
<td>14ECCE Ohrid, Macedonia 14ECCE Ohrid 750</td>
</tr>
<tr>
<td>393 07.09.2010</td>
<td>NMP Conference Brussels NMP Conference 1000</td>
</tr>
<tr>
<td>424 21.09.2010</td>
<td>IABSE Symposium Venice, Italy IABSE Symposium Venice 645</td>
</tr>
<tr>
<td>432 06.10.2010</td>
<td>Radisson Hotel Köln IRIS Application in Russia 28</td>
</tr>
<tr>
<td>435 12.10.2010</td>
<td>UN-Spider Bonn, Germany UN-Spider Workshop 111</td>
</tr>
<tr>
<td>443 24.09.2010</td>
<td>Shanghai, China ISRERM 2010 2000</td>
</tr>
<tr>
<td>451 1.02.- 5.02. 2010</td>
<td>Jacksonville, Fl, USA IMAC 2010 (International Modal Analysis Conference) 880</td>
</tr>
<tr>
<td>454 28 – 31.03.2010</td>
<td>University of Southampton, Southampton, UK 18th UK Conference on Computational Mechanics (ACME-UK) 215</td>
</tr>
<tr>
<td>456 06 – 08.09.2010</td>
<td>UPC, Barcelona, Spain Fifth International Conference on Unsaturated Soils (UNSAT 2010) 166</td>
</tr>
<tr>
<td>471 26.11.2010</td>
<td>Taipei, Taiwan International Collaboration 60</td>
</tr>
</tbody>
</table>

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A decision has been made on 2 key publications which will be books in the size of about 300 pages each. The good examples of previous publications from previous projects (refer to the book “Ambient Vibration Monitoring”, which is the bestseller nr. 1 in engineering sciences) where the entire subject is covered specifically with a representative collection of applications and an annex containing glossary and definition of major terms. It will not just be a collection of individual papers. The publisher J. Wiley has expressed definite interest in this books and has approached us already with an offer for a contract. A decision that these publications will be made has been taken by the Consortium already during the Summer Academy in September 2009 and confirmed 2010. The preliminary working titles and content of these publications are:
• “The Civil multi non-linear Condition Model” containing the economic as well as socio-economic background as an introduction; the new risk paradigm as a key innovation; the formulation and solution of the key performance indicators in the non-linear regime; the resulting IRIS decision support system; the underlying business case and the implementation of the concept into practice. A rough draft version is already available. Nevertheless the horizon for publication is spring 2012 to be on the market by the end of the Project.

• “Damping in Modelling and Experimental Practice”. This very complicated subject is also targeting the international collaboration aspect of the project. The international partners have expressed strong desire to participate in this publication and it was found that they have important contributions to provide. A draft has been provided which will be circulated soon for comment and proposals of contribution. Negotiations on this high level subject will start soon. The progress will be reported in the next period.

Demonstrations
Demonstrations are the best vehicles for dissemination and therefore are handled with priority in the Project.
Detailed descriptions of the various demonstrations within and above the description of work are given in previous chapters. In general it has been decided that demonstration results are given freely to anyone requesting it. The only exception is work package 1 where nuclear issues are tested which cannot be freely disseminated. So far no problems with dissemination or intellectual property rights have been registered.
Special provisions for free access will be made also sustainable after the end of the project.

Conferences and Symposia
Many members of the IRIS Consortium have been integrated in major user communities which perform conferences and symposia regularly. These are good occasions to reach a large number of potential users and a good platform for publication of our results. A detailed plan has been made already and preparation works are going on which are explained at the end of this chapter.
IRIS beneficiaries are well integrated in respective user communities and visit these conferences and symposia on regular bases. Detailed information is provided in each beneficiaries report as given in annex 6 to this document. This procedure will be continued in the next Period with focus on:
- The 8th international workshop on structural health monitoring in Stanford in September 2011
- The SMiRT conference in New Delhi in November 2011
- The Eurodyn conference in Leuven (Belgium) in July 2011
- The IALCCE conference on lifecycle costing and management which will be co-organized by IRIS in Vienna 2012.
The concept for dissemination will be modified using the experience of the past activities. Dedicated mini symposia on IRIS have not been very successful because the participants are mainly Project beneficiaries and not enough outside attendance has been registered. Therefore the contribution will be submitted under the general framework to reach a wider audience. Otherwise the activities have been very well accepted and received and will be continued.

Training
Training is particularly important when the level of application of high technology solutions has been low so far. This particularly applies in the construction industry and also in the new member states as well as Russia and GUS. Therefore training activities concentrate on these cases. Particularly Russia seems to be
a good market where money and willingness is available but proper information is lacking. For these reasons a decision has been made to put more effort into the Russian market which requires travel and training to be given on site. In addition to that Russian scientists and representatives are invited to join IRIS activities which has been successful already (for example the dissemination event in Cologne 2010 which has been followed by visits to Moscow where an opportunity for dissemination and training of IRIS developments has been offered). A decision has been made to produce well-maintained training material out of the excellent presentations and works presented in the summer academies. This material will be ready by the end of the Project.

Theses by IRIS Beneficiaries Personnel related to IRIS research work

08 USTUTT
Preliminary title: Piping Vibrations in Power Plants, Detection, Evaluation, Minimization in view of Integrity, Availability and Life Cycle Assessment
- Name of the applicant: Mr. Gereon Hinz
- Approximate duration: 2011 - ?
- State: In progress

21 CTU
- Title of the thesis: Effective Querying in Databases
- Name of the applicant: Bogdan Kostov
- Approximate duration: 2010 – 2014
- State: In progress

- Title of the thesis: Semantic Web-based Content Management System (Bachelor Thesis)
- Name of the applicant: Ji?í Kopecký
- Approximate duration: 2011
- State: In progress

25 BAM
- Title of the thesis: Risk Based Assessment of Existing Bridge Structures
- Name of the applicant: Ronald Schneider
- Approximate duration: 08/2010-07/2013
- State: In progress

- Title of the thesis: Damage Detection and Assessment of Engineering Structures
- Name of the applicant: Falk Hille
- Approximate duration: 06/2009-05/2012
- State: In progress

- Title of the thesis: Monitoring Based Condition Assessment of Offshore Wind Turbine Structures
- Name of the applicant: Sebastian Thöns
- Duration: 04/2007-03/2011
- State: Completed
29 UNIGE
- Preliminary title: Optimal form-finding algorithms for the control of structural shapes
- Applicant: Paolo Basso
- Duration: 2010-2013
- State: In progress

The subject has been included in the research activities performed by UNIGE in IRIS. We are also working about a Master thesis to be performed in collaboration with the University of Nantes (Francesca Lanata) on some subject concerning damage identification, but agreements are not finalized yet (mainly because of bureaucracy of EU programs).

31 U Cartagena
Title of the thesis: Reclamation of Soils acidified and polluted by mining activities: Undisturbed soil columns experiments.
- Name of the applicant: Ing. Mc. Dora Maria Carmona Carmona Garces
- Approximate duration: 208-2011
- State: In progress

- Title of the thesis: Landscape design for minimising environmental risks in SE Spain
- Name of the applicant: Arq. Mc. Sebla Kabas
- Approximate duration: 2009-2012
- State: In progress

- Title of the thesis: Soil formation from polluted residues after amendment application and phytoremediation
- Name of the applicant: Ing. Mc. Claudia Alejandra Salamanca
- Approximate duration: 2010-2012
- State: In progress

All of them belong to the Ph. D. Program "Environment and Sustainable Mining" from the Technical University of Cartagena. This program has been labeled by EU on 2011 (MOY labeled program): http://www.mediterraneanofficeforyouth.org/

36 CAS

- Title of the thesis: Research on Numerical Simulation of Interaction among Soil, Water and Structure in Rockfill Dam and Its Application
- Name of the applicant: HE Fan-min
- Approximate duration: 2007-2012
- State: In progress

- Title of the thesis: Research on the Constitutive Model of Hardfill Material and Stress and Deformation Analysis of the Faced Symmetrical Hardfill Dam (Master Thesis)
- Name of the applicant: DU Bin
- Approximate duration: 2008-2011
- State: In progress

- Title of the thesis: Seepage numerical method and engineering application in typical hydropower plants
- Name of the applicant: YANG Lian-zhi
- Approximate duration: 2006-2012
- State: In progress

38 VCE
- Title of the thesis: Seismic Hazard of Historic Residential Buildings – Evaluation, Classification, and Experimental Investigations
- Name of the applicant: Achs Günther
- Approximate duration: 2007-2011
- State: Completed

- Title of the thesis: Service Loads of Steel Bridges - Development of a new Monitoring-based Traffic Loading Model and Analysis of its consequence on critical structural members - exemplified at the Europabrücke
- Name of the applicant: Veit-Egerer Robert
- Approximate duration: 2004-2011
- State: In progress

Events
A culture of internal events has been developed already in the previous Periods. This has been very successful in the entire consortium is ready to continue this format. It has been recognized that the interests in IRIS events is growing. A sustainable solution shall be looked for.

Use of Foreground
Foreground has been used to develop a system for optimal infrastructure management. A case of data has been handed over by the new associated partner ASFINAG (a set of about 150 structures including all details) has been handed over and exploited using the foreground. This activity will be completed in Period 3 and an appropriate report will be prepared. The progress so far is very promising and the reactions of the owners and users has been seen extremely positive. Valuable input from industry has been received. These activities also have triggered national Projects which has been the intention from the beginning. They will be devoted to take up the developed methodologies from IRIS and transfer them into applicable solutions for industry.

Dissemination Meetings after the project
The following major dissemination meetings are planned after the project:
• EACS in Genoa (18. – 20. June 2012)
• EWSHM in Dresden (3. – 6. July 2012)
• IALCCE 2012 in Vienna (3. – 6. October 2012)
List of Websites:
www.iris-safety.eu

Database

Related documents


**Last update:** 29 March 2017  
**Record number:** 196603