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Plant Life Management Models with special emphasis to the Integration of safety with non-safety related programs

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Content

The reference background scenario for the policy

1. The generic trend towards the **extension of the operating life** of the existing plants. Such life extension requires a detailed review of the original design assumptions, also reflected into current **maintenance practice**, and the continuous monitoring of the component reliability (performance goals) in order to support a suitable trend of the safety evaluation beyond the design life.

2. **The open electricity market**, which is going to be a reality in most of the European Countries in few years. Such economical and financial framework demands for significant reduction of the generation **costs**, very strict investment planning, outsourcing, controlled reliability of the equipment and components (incl. obsolescensce) and therefore for reliable indicators of the effectiveness of the maintenance programmes

2) The “safety issue” – the PLIM framework

a. PSR versus LTO-PLEX programs. PLIM models
b. LTO objectives
c. LTO scope
d. Preconditions and LTO-specific tasks
e. The “required level” of safety
f. The safety margin in the long term
g. Which degradation mechanism
h. Human related issues in LTO
i. LTO implementation issues at WWERs and other plants

a) PSR versus LTO - Feedback

- **PSR as a rational approach** (not the only one) to deal with the cumulative effects of: plant ageing, plant modifications, operating experience, science and technology developments, site hazard modifications, but **cannot be used** for the removal of the long term technological constraint on plant operation.
- Ageing is a major **safety related program**: prevention of damage, evaluation of the real damage (in view of LTO), emphasis on long lived passive components (excluded by standard maintenance)
- Difference between ageing management (safety concern) and **life management** (optimization, return of investment)
- Importance of ageing man. program set up from the **beginning** of the plant operating life, or as soon as possible. AMP needs time
- **Difficulties in the implementation** of AMP for existing plants and in their grading in a feasible time framework

PSR versus license extension

- **Full scope PSR** may be implemented every 10 years: it is expensive (about 200 man/years)
- **License extension** is done very few times, but it does not provide **continuous** confidence on the safety level of the plant. It is usually coupled with a continuous AMP
- Some countries select a **balanced mix**:
  1. Limited scope PSR (only R&D, ageing, communication) every 10 years
  2. License extension for "expected" degradation mechanisms (TLAA), safety requirements, etc. for 20 years

  (Note: the **involved SSCs** are different between the two steps!!)

The LTO may be **extended for ever**, but economical considerations usually provide an upper bound!

PLIM models

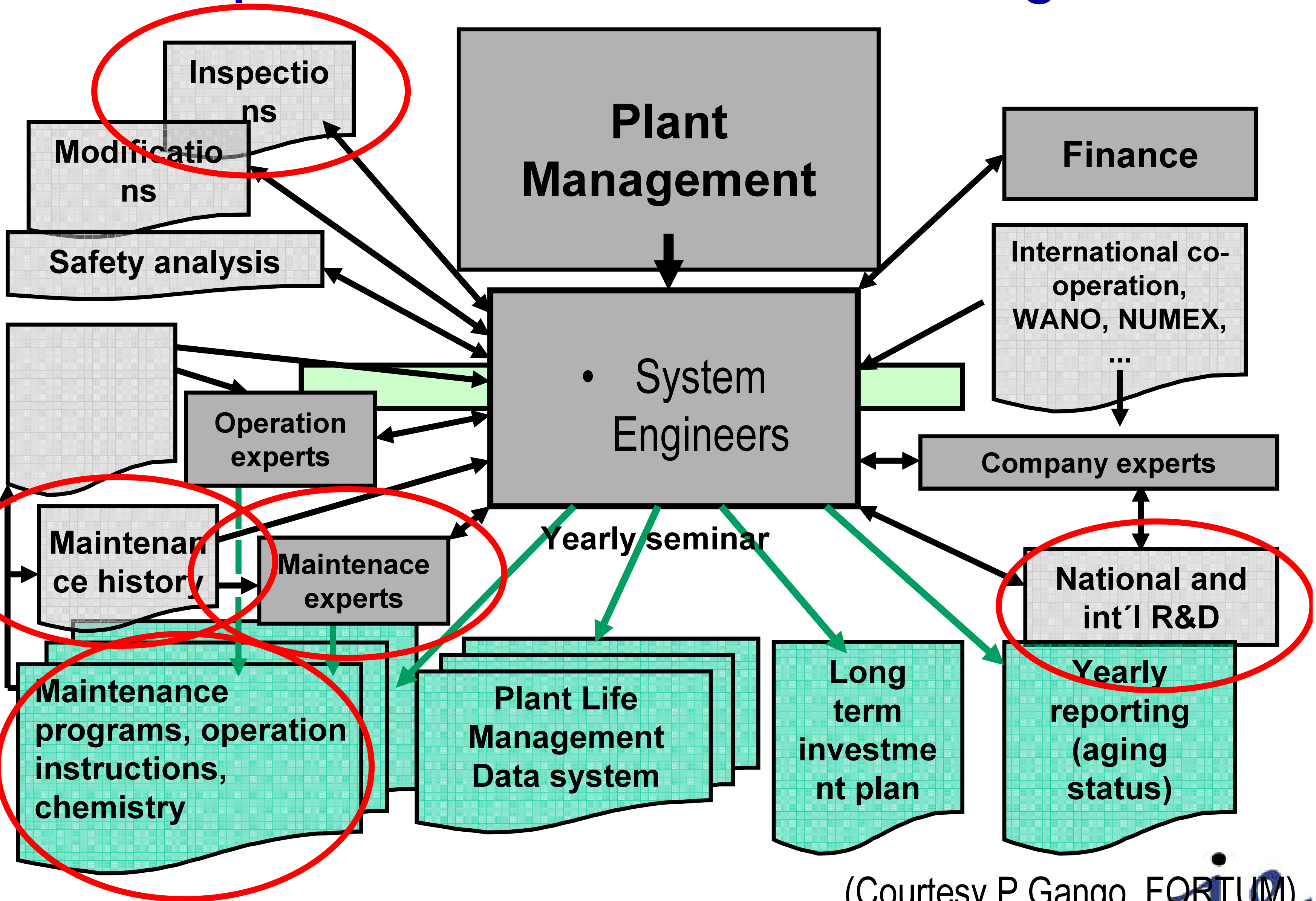
Optimal integration of:

- Operating cost optimization
- Safety and asset management
- Safety culture safety performance indicators
- Knowledge management issues

An example of PLIM

(Courtesy P.Gango, FORTUM)

Example of PLIM - AMP management



(Courtesy P.Gango, FORTUM)

The regulatory control on LTO

Existing frameworks are rather different and a generalisation is not possible:

Regulatory system	Utility	License LTO	Example	
"Continuous" model	Continuous	Term	PLEX	USA
PSR model	Continuous	Term	PSR	France
PSR model	Continuous	No term	PSR	UK
PSR model	PLIM	Term	PSR	Finland
PSR model	PLIM	Term	PLEX+	Hungary

- In most cases PSR is applied as a standard regulatory tool but **it is not used for LTO** as it is considered not useful for a long term operation (I.e. beyond 10 years). It is then coupled with a PLEX system
- In most cases PSR provides a periodic regulatory check-up of the plant safety, but the plant applies **a continuous PLIM**

Differences?

LTO, LR. PLEX, PLIM, PSR, AMP may have very similar tasks. What is different is the objective (asset management, regulatory control, safety improvement, etc.) and the regulatory contribution/visibility

As soon as a comparison is carried out at the technical level, without reference to the licensing/regulatory framework, tasks are quite similar!!

In all frameworks, the role played by MS&I programs is crucial

b) Pre-conditions and LTO tasks

- **Preconditions for LTO**: tasks needed to **reach** the **required level** of plant safety and to prove it

- **LTO specific tasks**: tasks needed to **maintain** the **required level** of plant safety in the long term in relation to material ageing, technological obsolescence and staff knowledge, beyond the plant life defined at the design phase by the technological limits

Pre-conditions and LTO tasks

Pre-conditions – Required also for current operation during design life (see for example the **safety factors** of the PSR)

- Updated SAR
- Updated EQ
- Updated design basis
- Updated EE hazard
- Updated safety analysis
- **Appropriate maintenance program**

LTO specific tasks – Affected by the extension of the beyond design basis lifetime

- Trend analysis of material and component degradation
- Staff ageing
- Technological obsolescence
- Public acceptance
- Environmental issues (population, installations, emergency planning)

c) Maintenance and PLIM

All Countries implementing an LTO/PLEX program applied **extensive** modifications to their requirements on maintenance at first step, setting up mechanisms to monitor the effectiveness of the maintenance activities. In particular, the following features are **believed to be indispensable** for a maintenance program acting as a precondition for a PLIM:

1. **Monitor the performance** of the SSCs (structures, systems and components) which may have impact on safety during all operational statuses of the plants;
2. **Assess and manage the risk** that may result from the proposed maintenance activities in terms of planning, prioritisation, and scheduling.

Basic attributes of the MS&I program

- The identification of the **scope** of the condition based maintenance rules: typically the Countries choose the safety related SSCs, SSCs which mitigates accidents or transients, SSCs interacting with safety related SSCs, and SSCs that could cause scram or actuation of safety related systems. Therefore, many non-safety related SSCs may see the application of such maintenance rules, with augmented efforts in monitoring their performance and planning their reparation.
- The setting of the performance **goals** for every component in the scope of the maintenance rules, ranking them according to their risk significance for the plant safety. This task may end up very challenging as, when industry experience is not available, either dedicated PSA tasks have to be developed (with special requirements on PSA quality) or special qualification programs for the evaluation of the component reliability.
- The performance **monitoring** techniques for the very broad categories of structures systems and components in the scope of the rules.
- The assessment of the safety **during implementation** of maintenance actions.
- **The feedback from the result of the monitoring of the component reliability back into the inspection, surveillance and maintenance procedures. Root cause analysis, equipment performance trend analysis and corrective actions have to be developed on a case by case basis.**

3) The "cost issue"

The analysis of the practice in the EU countries highlighted the following priorities:

- Reduction of unnecessary tasks and optimized maintenance periodicity, through better **scheduling** of maintenance activities, minimization of outages duration and optimized work control
- Optimization of the management **organization**, more suitable to control plant safety
- Coping with the "complex organization development work", which is recognised to be a potential cause of accidents incubation (supplemental workers, etc.)
- Optimized **integration** among existing safety programs, such as: ISI, AMP, configuration management, design basis reconstruction, etc.
- Reduction of the **human factors** impact during maintenance activities
- Minimization of the **radiation doses**
- Sharing **spare parts** through networks

Organizational challenges in optimised maintenance of Nuclear Power Plants

Key needs emerged during the SENUF Benchmarking exercise:

- Need for cutting maintenance expenses;
- Coping with the "complex organization development work", which is recognised to be a potential cause of accidents incubation and a source of high costs;
- Definition of a "strong basis for long term partnership with highly qualified and technically skilled contractors";
- "Reduction of the human factors impact during maintenance activities".

Some additional technical issues

- In some European plants maintenance tasks and their periodicity is still defined by the suppliers of the systems and components
- The ISI program still is not fully integrated into the PLIM in many cases. The RCM approach helps such integration focussing on the component reliability, in time.
- Human factors show a very high incidence during shutdown due to maintenance works
- Large use of supplemental workers makes work control more difficult. Maintenance effectiveness indicators are needed to optimise the process
- The operation feedback has to be collected on the broadest basis of NPPs

Countries' experience

In relation to the operating cost reduction as a consequence of the application of optimized maintenance programs such as the RCM (Reliability Centered Maintenance), the participants to a IE questionnaire highlighted the following reductions:

- In Sweden, **10 - 20%** of the effort, especially for I&C calibration intervals
- In Spain, **20% in work, 30%** in number of tasks
- In Hungary, expected, not quantified
- In Czech Republic, **30%** on a restricted number of systems selected for a benchmark (according to the implemented Phare project in Dukovany NPP)
- In Slovakia, expected, not quantified.

Need for maintenance support tools

- To provide lightweight 3D resources to help with the preparation of job site unit shutdowns: **to study, capitalise on and share maintenance** job site scenarios in reactor buildings.
- To prepare job sites **before the start** of work and analyse the risks without going into the building. During work, in the event of problems for a better perception of impacts and to study emergency scenarios.
- **After completion of the work** to obtain feedback and capitalise on and share good practices.
- To provide nuclear sites with a 3D tool to improve the **preparation and monitoring** of packing (movement and management of the dimensions of components) during maintenance operations.

Some example experience in the development of support tools

- Tools for maintenance optimisation
- Tools for outage optimisation
- Data bases for integration of ISIS and Maintenance issues
- Procedures for the workflow management
- Methods for ageing evaluation and optimization of component maintenance
- Methods for risk monitoring, on-line safety assessment
- Etc.

4) Summary of priorities

In order to meet the general safety and cost objectives, the following priorities were highlighted by the preliminary phases of the research:

– Technical: integration of safety programs, RCM, ageing control, analysis of operation feedback

– Organisational: PLIM, asset management, integration of safety and non-safety programs, human performance, supplemental workers, indicators, outage optimisation

– Tools development: simulation, support to maintenance, recording, etc.

Organisational issues should be tackled in parallel to technical issues

5) How to carry out the research?

Develop R&D on the following areas:

- **Organizational factors**, in order to improve the character of cross-cutting issue of the maintenance programme, where all the available information on SSCs have to concur to the overall control of the plant safety
- **Reliability centred maintenance**, where risk related information support the control of the overall plant safety
- **Integration of Maintenance with ISI and AMP**, where improved control of material and component ageing needs close interfaces with the maintenance programme to support the safe plant performance in time.

SONIS objective

To face the technical, research and organisational issues in **Operational Safety** (for both short and long term operation), with emphasis to optimised **maintenance** programs and qualified **ISI** programs, effective **engineering** programs (seismic and fire protection) and improved control of **human factors**

The three **legs** of SONIS

SONIS

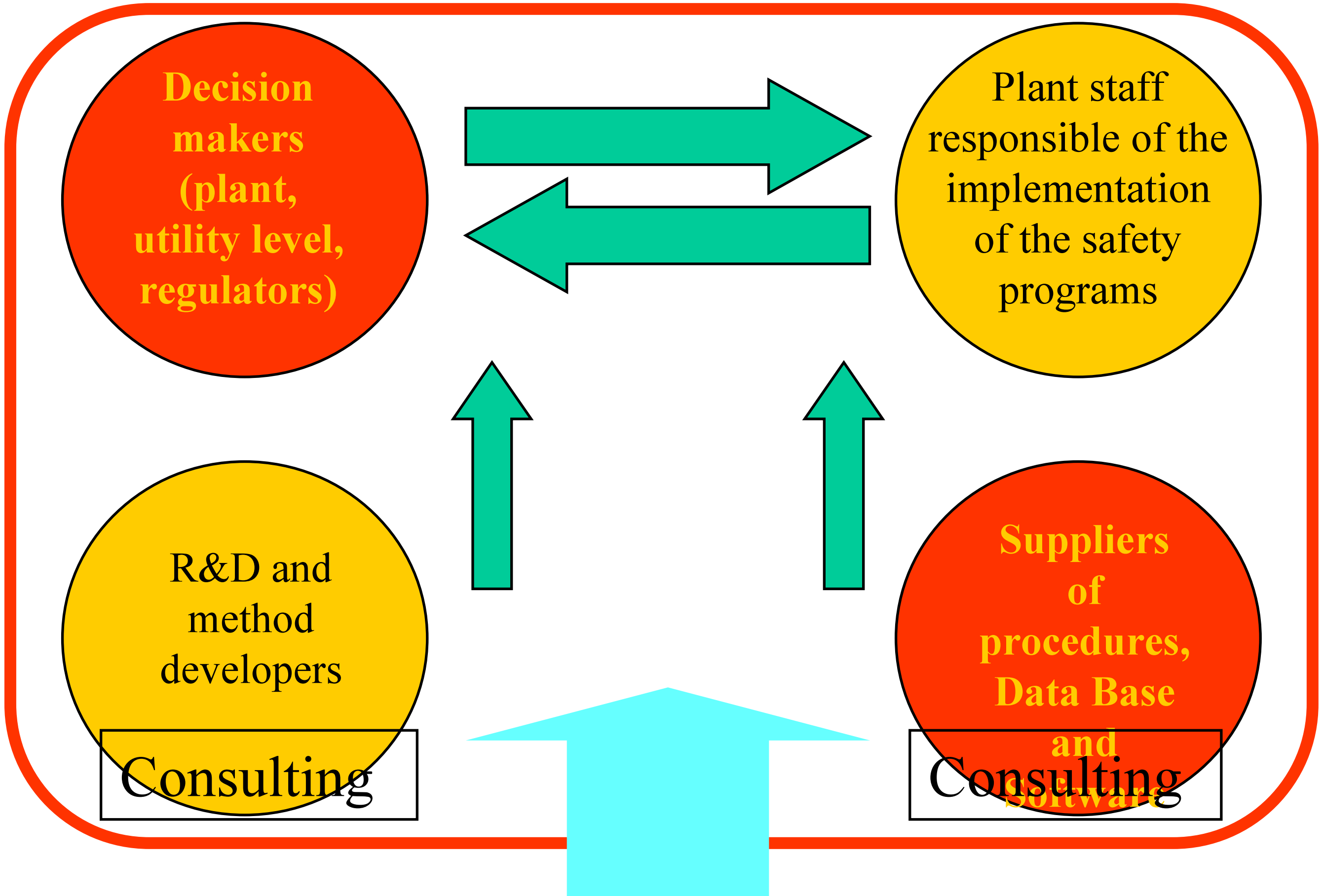
Maintenance, Surveillance and In-Service Inspections (MS&I)

Engineering programs: Fire prot. and seismic issues

Plant Organisational Issues

(Also in agreement with the IAEA Operational Safety Requirements NS-R-2)

The SENUF network at the JRC



JRC-IE as facilitator and R&D provider

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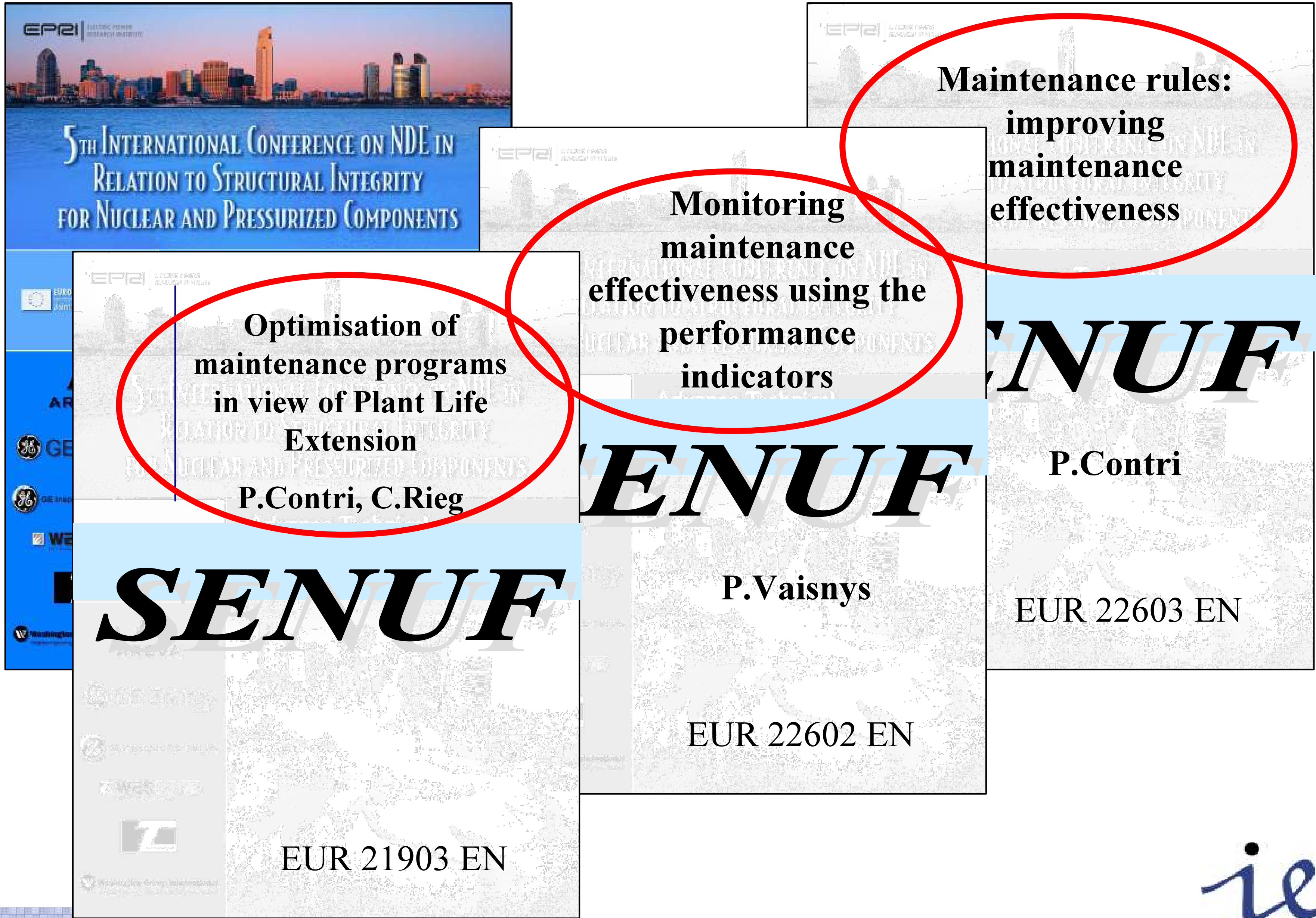
The SENUF network - Deliverables



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Outcome / Deliverables

- Models for maintenance optimization and PLIM
- NDT Qualification and Risk informed ISI concepts, guidance and practices
- Specific risk assessment techniques, relevant to the modification of traditional programmes for MS&I (Maintenance, Surveillance and Inspection)
- Equipment qualification procedures and data bases in relation to fire safety
- Self-assessment methodologies for safety culture issues in operating organizations, testing and improving methods and tools for the knowledge management at the plant organisations, reference models for operating organizations with effective integration of the safety programs

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6) Conclusions

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- A European network on maintenance optimisation issues is now in place, open to all stakeholders (Utilities, Regulators, Consultant, SFW developers, etc.): too many countries do not have a “critical mass” for experience exchange, document exchange, benchmarking, etc.

- Research is essential, many research tasks are needed : SONIS direct action and/or FP7 indirect funding, both in coordination with the other available experiences

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