Instrumentation and control; Man machine interface (MMOTION, ADVANCE, HARMONICS)

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**Instrumentation and control; Man machine interface**

Nuclear power plants are

- **steered by** automatic functions
- **supervised by** operators in the control room

Failure of electrical system and wrong decisions by operators will transfer the plant **into disturbances** or **complicate the outcome** of disturbances.

EU-research project MMOTION, HARMONICS, ADVANCE will support advanced knowledge within these areas

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- **HARMONICS** - Harmonized assessment of reliability of modern nuclear I&C software.

- **ADVANCE** - Ageing and prognostics of low-voltage I&C cables

- **MMOTION** - Man-machine organization though innovative orientation for nuclear

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Main goal for the projects have been to

- Transfer knowledge and insights from different countries
- Develop best estimate or harmonized views on ways to increase plant safety
- Establish partnership for long-term programs
- Develop basis for European training programs

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**HARMONICS** led by VTT

participation from 5 different countries and organisations

- EDF (FR), *Utility*
- SSM(SE), *Regulator*
- VTT (FI), *TSO*
- ISTec(GE), *Consultant*
- Adelard (UK), *Consultant*

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The overall objective of the HARMONICS project is to ensure well founded and up-to-date methods and data for

• assessing software of computer-based safety systems.

By assessing different approaches to systematic and consistent, yet realistic and practical approaches for

• software verification,

• software safety justification

• quantification of software failure rates.

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The 5 partners in got insights in
• Existing knowledge
• Existing practices
• National guidance and regulations
• Existing tools and methods

in the participating countries

A close collaboration have been established

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Based on the performed work *(50 % of the project)* the members have developed understanding of

- relevant failure modes
- important aspects effecting the failure rate of software
- common methodologies to perform formal verification
- strength and weaknesses of simulation tools

for software on component level

The benefits and weaknesses of *statistical testing* have been assessed and common understandings have been developed among the partners.

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The output from the project will give:

- recommendations on how to make effective verification of software for digital components
- be a good basis for developing training programs for regulators and industry in performing verification of digital components.

This will support the implementation of digital components in safety functions in nuclear power plants.

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HARMONICS

• has established contact with organizations like MDEP and ENSREG to discuss how demands could be specified on digital components this also includes contacts with similar work going on within IAEA and EPRI.

• has developed an END-USER program in which 100 persons are listed. One END-USER workshop has been performed with 30 participants from regulators, utilities and research organizations.

• could have give a broader impact if one or two vendors and also experts from other countries had joined the project.

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HARMONICS has

not developed
-new verification methods

not assessed or
-failure modes on system level

These are areas for coming European project

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Questions for the the future related to HARMONICS

Will the outputs be
- transferred to standardisation organisations
- reviewed by a large group of regulators
Will recomendations be used
- by the industry
- to start new research to solve identified weaknesses
- to initiate research to verify software on system levels

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**MMOTION**

have the following 11 partners

**Industry** - EDF, Brittish energy

**Research institute** : NRI, VUJE, CEA, ISAR, VTT, IFE

**Consultants**: ATOS, ERDYN

**Vendors**: ABB

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**MMOTION** have assess the need and feasibility of new research projects related to human performance for

- design of human technology systems
- operation
- evaluation and assessment of human factors

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**MMOTION** reviewed industry needs in the following areas

- Risk-informed approaches for design and operation
- Industrial issues in MMO design
- Culture and practices for safety
- Integrated design approach

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The following steps were included in the MMOTION project:

- Characterize the current situation
- Identify trends
- Build a vision of the future
- Identify expected results
- Identify critical points
- Specify required technologies and/or methodologies
- Select technologies and/or methodologies
- Built an action plan
- Define action plan timing
- Create a roadmap report
- Discuss and validate results

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The main general objectives of the MMOTION program are

- To provide a sophisticated (risk oriented) framework for identification and assessment of deficiencies and possible improvements of current NPPs design and operation from human factor perspective.

- To strengthen objectivity of safety judgments by using methods of advanced risk-oriented decision making in human reliability area.

- To improve cost-effectiveness and balance of safety provisions.

- To adapt methods of treatment of human caused risk for specific features of operational conditions of new generations of nuclear reactors.

- To extend the area of application of progressive methods of human related risk based analysis over new areas (organizational factors).

- To provide necessary objective inputs into the probabilistic safety models integrating human and machinery contribution to operational risk into one common framework.

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- **Risk related Approaches**

Four steps of intensity of risk oriented decision making involvement into NPP operation:

- **First step:** Something new, interesting, promising, should be investigated further…

- **Second step:** Yes! It is interesting and may be really helpful!

- **Third step:** A process should be established to use risk oriented decision making continually, on regular basis….

- **Fourth step:** Why do you not think about the problem from risk oriented perspective?

MMOTION believe that we are somewhere in early phase of the third step and that we should do our best to complete all steps.

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- **CULTURE AND PRACTICES FOR SAFETY**

To gain better knowledge and understanding of:

- Factors influencing safety culture and their measurement,
- The impact of changes in the organisation’s external conditions on their robustness and their vulnerability,
- Management practices in different NPP’s, teams and European countries and their generic strengths and weaknesses,
- The potential effects of new technologies on staffing and the dependence of staffing requirements on the plant’s lifecycle,
- How teams behave and the critical factors that influence plant performance and safety,
- The effectiveness of tools applied to assess human performance,
- Assessment of workload in complex tasks with multiple operators engaged in multiple and potentially conflicting sub-tasks.

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- **SOLUTIONS FOR BALANCING I&C RELIABILITY AND FUNCTIONALITY**

  Establishing coherent design principles for safety-related and non safety-related I&C functions

  - Designers have to manage conflicting objectives
    - Systems with high levels of reliability
    - Complexity of modern plants
  - Present systems have composite architectures with
    - high reliability
    - high sophisticated and less reliable functions
  - Operational safety issues
  - Technical requirements for I&C and automation should be balanced with the safety requirements in order to avoid performance impact of the end –users and so a lower safety level of the socio-technical system

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FEEDBACK ON THE PROJECT

- Team building is a key of success
  - To establish early working rules
  - 6 months are necessary to make people understand each other
  - To build a common vision
- Mixing work in large audience and small groups
- Meetings on 3 days are necessary, every 6/7 weeks
  - Homework sometimes delivered late …
  - Conference calls are efficient
- Necessary to share responsibilities
- External help for administrative management is very appreciated

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THE FOUR PROPOSED RESEARCH PROGRAMMES

RP1 Risk-informed decision making in design and operation
- implement risk-informed decision-making principles and techniques to MMO-related aspects in the design and the operation of nuclear facilities.

RP2 Culture and Practices for Safety
- optimizing the performance and robustness of the organisations in charge of operating nuclear power plants focusing on the human, organisational and management dimensions of the NPP system.

RP3 Integrated Design Approaches
- achieve a better integration of technical, human and organisational aspects in the various activities of the design process.

RP4 Technologic requirements on nuclear and other high risk industries
- optimisation of NPP I&C lifecycle through a better consideration of the specific needs of nuclear installations by I&C suppliers with special regard to integrating standardized nuclear requirements with respect to safety, availability and usability.

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EXPERIENCES 2,5 YEARS AFTER THE END OF THE PROJECT

• No new projects have been initiated

• Created teams and networks are splitted

• No clear responses from industry or regulator on the usefulness of the proposals

• No actions towards standardisation organisations

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ADVANCE

11 partners from - utilities, vendors, research organisations:

Industry: Forsmark(SE), EDF(FR),

Research institute: KTH(SE), NRI/REZ(CZ), CEA (FR),
Univeristy of Bolonga (IT), Chemistry Institute, Jadrowej (PL),

Consultants: Tecnatom(ES), NEXCAN(GE), Belgich laboratorium (BE),

Vendors: Westinghouse (SE)

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ADVANCE - contain
• Assess methods to performing condition monitoring (CM) of cables in existing nuclear power plants
• New assessments of novel monitoring techniques should extend service lifetime and minimise faults and reduce costs for the utilities
• Degradation mechanisms and profiles will be important in planning lifetime extensions to existing plants as well as in selecting cable materials and configurations for new plants.
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ADVANCE - contain

• Scientists are studying the performance of electrical CM techniques in assessing selected cables in European NPPs for comparison with more conventional techniques

• Researchers are evaluating both global (bulk) ageing simulated through accelerated thermal and radiation ageing tests along the entire length of a cable as well as local (hot spot) ageing due to a nearby heat or radiation source. Characterisation of test results including electrical responses will lead to correlation with diagnostic criteria.

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ADVANCE – contain

• Analysis of insulated materials including their additives (antioxidants, fire retardants, pigments, etc.) of six different cable types from an inventory of European NPPs are performed. Ageing protocols are being carried out for both sequential and simultaneous ageing processes and electrical CM is underway. In addition, the measurement of physical and chemical properties under various conditions will be used to predict electrical properties based on physico-chemical degradation. Simulations complement experimental work for continual refinement of both techniques. Finally, scientists are designing novel cable design based on results.

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- The partners in ADVANCE have learned that there exist a lot of knowledge within European countries not easily available or accessible. The partners within ADVANCE have exchange detail information on existing praxis within the field of cable design and testing.

- ADVANCE has also been able to establish a platform for assessing different methods for assessing different damages of cables. This has also resulted in a better understanding of which failures that are difficult to detect.
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- The testing in ADVANCE-project have also indicated that the insulation of cables are not always homogeneous along the whole cable length.
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Common lessons learned from the projects (MMOTION, ADVANCE, HARMONICS)

4 phases

Phase 1- Start-up

Phase 2- Working phase

Phase 3- Summing up and development of recommendations

Phase 4- After the project

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**Phase 1- Start-up**

Each project has a start-up phase in which partners get to know each other and the skills and tools used by the different organisations. In this phase the partners also get to know the different national standards and praxis established for the specific technical area. This is a very important phase and transfers a lot of knowledge among the partners.

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Phase 2- Working phase

Each project has a second phase when the work packages are performed according to the project descriptions. This also includes contacts with external partners in some cases contact with an END-users group. During this phase the partners practice to use other methods and data. The projects also include a lot of discussion about strength and weaknesses in the performed assessments or calculations.

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Phase 3- Summing up and development of recommendations

The third phase is the phase in which the results are put together and the summary report are delivered. At this time the partner have established a good relation and learned a lot from each other.

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Phase 4- After the project

- The fourth phase comes after the project. In this phase the members of the project is splitted and if no new project is initiated the good connections disappear. There is no mechanism to follow up if the results of the projects is used
  - within the member organisations
  - as basis for new projects
  - for training purposes
  - for developing new standards

There is a lack of ownership that promotes the use of the outcomes for any of these listed purposes.

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**Recommendations to EU-research**

It is of importance that organisations as **NUGENIA, ETSON and FORATOM** support the decision on how to take care of outputs and recommendations of performed research.

The **roles of regulators** to assess the result are also an important issue as the new knowledge can give insights on how regulations shall developed but also on how to initiate other actions based on the results.

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Recommendations to EU-research

It will be of importance to find ways to:
- Promote and use the lessons learned from EU-project
- Evaluate the usefulness of the result in all European countries – regulators and industry
- Specifications of complementary research or other actions needed to make the result usable
- Transferring the "ownership" to existing networks that can promote the use of the results
- Get the outputs assessed by "standardisation organisations"

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Thanks for listening

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