# Nuclear safety research: past achievements, new goals

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The Fukushima accident brings severe accidents statistics worldwide to a level which is well above the generally accepted goals for nuclear safety, of no more than one accident per 100 000 reactor.year. The repetition every thirty years or so of such catastrophic accidents is of course unacceptable to societies, and it is imperative to further enhance the safety of nuclear technologies.

Following the TMI and Tchernobyl accidents, large nuclear safety research programs were launched internationally, which led to significant progress in the understanding of the phenomena which could lead to such accidents, of their potential radiological consequences for people and the environment, and to the definition of operational approaches to reduce their occurrence and help mitigate their consequences.

Unfortunately, thirty years later, the Fukushima accident draws the attention to several disturbing facts from a scientific perspective:

- If a majority of LWRs worldwide have been modified over the years to take into account the major results from such international research programs, through ongoing efforts to enhance safety, this has by no means been systematic. The question arises of the reasons why such existing knowledge has not been fully implemented.
- It has been common practice, until now, to ignore extremely low probability events or combinations of events which could constitute accident initiators. Such practice is questionable when it is applied to current reactor technologies, developed for their most part more than half a century ago, which do not take into account severe accident consequences in their design basis: whilst it leads to apparently satisfactory probabilistic results, this practice amounts to actually accepting running a very low, but also very real risk of unavoidable important damage to society, with the possible long term loss of territories, following a severe accident. It also leads inevitably to an insufficient scientific investigation of the natural hazards and other conditions that characterize such low probability events.
- The existing knowledge on understanding the effects of chronic environmental exposure to low doses of radiation, on humans or on ecosystems, is still fragmented and incomplete. This situation renders the task of managing situations in territories affected by large accidental consequences radioactive releases extremely difficult from the point of view of the societal acceptability of decisions taken by the competent authorities.

The scientific community of expert and research organizations engaged in nuclear safety and radiation protection is a key stakeholder in any international roadmap for strengthening good practice in these fields. Studies by OECD/NEA have shown that by the end of the 1990's, significant reductions occurred in the level of resources dedicated to safety oriented R&D, leading to the actual closure of many experimental infrastructures, some of them unique in the world.

The significant increase of the quality of international cooperation, thanks to efforts from all sides, has in part mitigated the consequences of such cuts in resources. However, the net result is today a clearly insufficient number of senior experts worldwide in full possession of the detailed knowledge of reactor and nuclear fuel behavior in accidental situations, a crucial resource at a time when a number of countries are considering the construction of new reactors, and when other countries are examining the potential for prolonging the operational life time of existing reactors. There has been in recent years a noticeable shift from science basis to rule basis in safety management. Could the multiplication of rules be a surrogate for reduced science and technology based expertise?

NEA competent committees have adopted jointly a strategy to cope with these complex issues. IAEA has also adopted at an international conference organized in 2010 in Tokyo a series of recommendations in favor of developing and bringing together in a networking effort the so called TSO organizations across the world, in order to consolidate expertise capabilities, and make them more readily available.

The international community calls for reinforced safety standards, to be implemented with increased vigor. Such reinforcements need to be based on state of the art scientific knowledge in order to be fully effective. It is therefore essential that further resources are committed to research programs on key issues such as:

- Fuel degradation in spent fuel pools in case of loss of coolant.
- Fuel behavior following a loss of coolant in vessel accident.
- Behavior of reactor containments in severe accident conditions, including the performance of venting and filtering devices.
- Systematic analysis of low probability events and natural hazards with a potential to be accident initiators. This approach, coupled to the further development of reference probabilistic studies for key reactor technologies would complement what already exists in terms of operating experience analysis for the most frequent internal events.
- Development of methods to reinforce defense in depth in reactor technologies, including through the development of more resilient backup systems, and off site technical support.
- Instrumentation and control technologies, including digital technologies at one end of the scale, and robust as well as resilient technologies to maintain for the operators a safe access to key safety parameters even in circumstances of an important degradation of the reactor facilities.

The management of radiological emergencies would also benefit from research investments into reliable methods for rapid identification and quantification of internal contamination with key radio nuclides, and into a better foundation in new radiobiology research data for the radiation protection rules concerning chronic exposures to low levels of ionizing radiation.

Existing nuclear technologies cannot achieve the desired high levels of safety without significant investments info safety developments, both for existing reactors and for new generation reactors and their sitting circumstances. Such investments will largely result from regulatory requirements. But they should as much as possible be based on innovative science based approaches which should be encouraged by the international community, and which the international scientific community of expert and research bodies has the responsibility to produce in a timely manner.