FRENCH SMRS: LESSONS LEARNT FROM TWO

YEARS OF REGULATORY SUPPORT

FOR SMR PROJECTS

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**Abstract**

Following the launch of President Macron's 'France 2030' plan in February 2020, a dozen SMR designers have contacted the Département de la sécurité nucléaire (DSN), the French nuclear security authority, to seek regulatory support for implementing security by design.

SMR projects pose challenges for the DSN as the designers lack practical knowledge of nuclear security and do not have access to classified information such as the DBT. These projects are planned to be installed in great numbers in locations where there are no nuclear facilities today and near populated areas. This represents a complete paradigm shift from the current French nuclear location.

The DSN had to adapt and create a new process to support SMR designers.

This paper will present the lessons learned related to the challenges faced and how the DSN addressed them, including the optimization of human resources, coordination with other competent authorities, drafting a guidance on security by design for SMRs and a step-by-step approach for technical dialogue on protected information, particularly for DBT.

## INTRODUCTION

For the first time, nuclear power was mentioned as a solution for fighting global warming in the final agreement of COP28. The increasing interest in nuclear power, particularly due to its enhanced safety performance and potential for closing the fuel cycle, has positioned it as a significant asset. Small modular reactors (SMRs) are at the forefront of this interest, offering flexibility, modularity, and smaller sizes compared to traditional reactors.

The French government, through its "France 2030" initiative, has acknowledged the challenges and opportunities presented by nuclear power in research and development. To support innovation, "France 2030" plans to invest 1 billion euros in public funds to support the development of innovative nuclear reactors and foster the emergence of new comers in this field. This support extends to both nuclear fission and fusion reactor concepts. In response, several French project leaders have participated in "France 2030" and secured subsidies.

Approximately ten project leaders in France are at various stages of their projects, all aiming to have operational reactors by 2026 or within the 2030s. Some companies are ambitious, targeting the deployment of hundreds of reactors by 2050. Recent developments have further underscored the global momentum behind SMRs.

Additionally, innovative SMR designs continue to evolve. Companies are exploring advanced cooling systems using liquid metals like sodium and lead, as well as high-temperature gas-cooled reactors using helium. These designs promise enhanced safety and efficiency, and the use of advanced fuels like TRISO (tri-structural isotropic particle fuel) and HALEU (high-assay low-enriched uranium) should become more common.

Overall, the progress and support for SMRs highlight their critical role in the future of nuclear energy and global decarbonization efforts. The initial contact with project developers was made two years ago with the French Nuclear Security Department (DSN). As a result, a well-established process has been put in place by the DSN to provide support and appropriate instruction to the various designers.

## nuclear security: process set up bY the authority for smr

In France, the nuclear energy landscape has been predominantly shaped by large companies operating well-established installations, with extensive collaborative experience between operators and regulatory authorities.

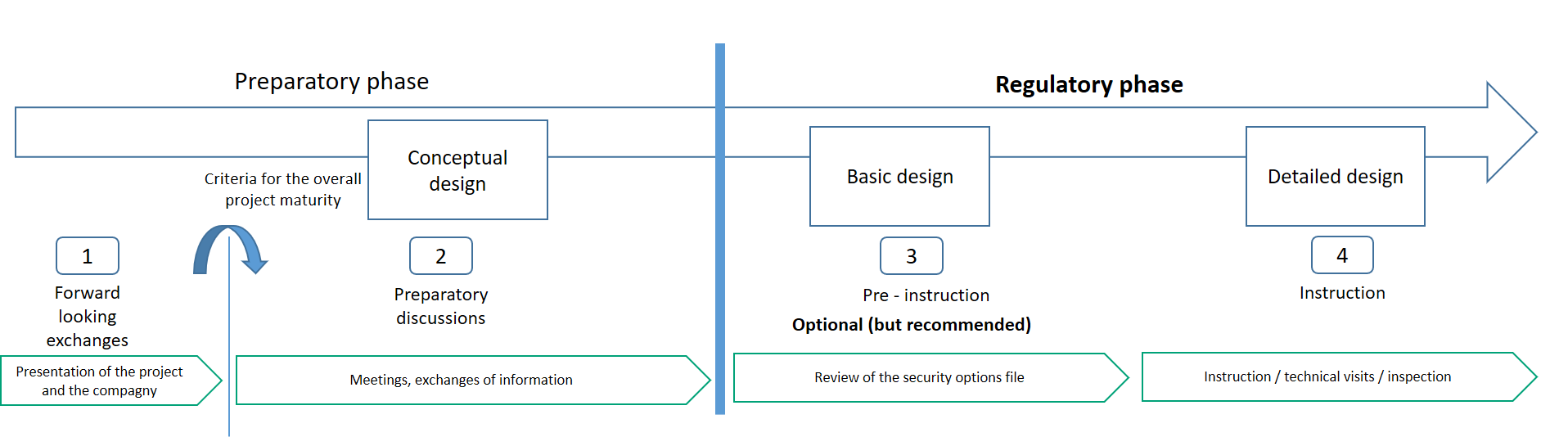
These nuclear sites, constructed several decades ago, now accommodate new facilities such as the Flamanville EPR reactor. While the concept of "security by design" is implemented, it remains limited due to the pre-existing security framework based on the confidential French nuclear Design Basis Threat (DBT).

Small modular reactor (SMR) projects introduce distinct challenges for the French Nuclear Security Authority. Unlike traditional operators, SMR designers lack practical experience in nuclear security and do not have access to the DBT. Currently, around ten French SMR designers, working with various innovative technologies (including molten salt reactors, lead-cooled fast neutron reactors, sodium-cooled fast reactors etc.) are in contact regularly with the Authority. Projects, ranging from 10 to 540 MWth, also propose the establishment of fuel plants, thereby extending the scope beyond reactors to encompass the entire fuel cycle.

The emergence of SMRs signifies a paradigm shift, as designers aim to place these reactors close to industrial sites that require heat, potentially near inhabited areas previously unaffiliated with nuclear power. This shift necessitates a comprehensive adaptation of security strategies and regulatory frameworks.

### Organization in the French Nuclear Security Department (DSN)

To assist SMR designers in aligning with existing regulatory standards, the French Nuclear Security Authority has developed a tailored approach that emphasizes early engagement and ongoing dialogue.

The DSN operates in two distinct phases: the preparatory phase and the regulatory phase. The preparatory phase allows for early discussions with project developers, starting at the earliest stages of the design process. The regulatory phase involves the examination of a security option file (an optional measure). The DSN can initiate a preliminary investigation of this security option file and engage in discussions with the project owner. Once an authorization application is submitted, the DSN will review the designer's application for authorization to hold nuclear materials based on a detailed design (see figure below).

*FIG.1. Instruction process in the Nuclear Security Authority*

This process, established by the DSN, enables designers to become aware of nuclear security issues at the earliest possible stage and to consider key points outlined in the subsequent paragraphs. The DSN has created a guide to serve as a reference for discussions with designers.

Additionally, the DSN has strengthened its cooperation with other government departments, particularly the French Nuclear Safety Authority (ASN), to ensure parallel progress on both safety and security issues.

Given the current situation, additional resources have been allocated to the Nuclear Security Department to handle the increased workload required by the DSN to process SMRs. One full-time equivalent (FTE) has been assigned to ensure national and international coordination on the subject and to assist project developers in understanding French regulation. Two full-time equivalents have been mobilized to facilitate technical exchanges with designers based on their designs and to review applications for authorization or security option files. The Technical Support Organization (IRSN) is also involved in this process.

### Guide for small modular nuclear reactor project developers, regarding French regulations

A concise, non-classified guide has been created to elucidate the regulatory framework, nuclear security principles, technological choices, information protection, cybersecurity risks, and the integration of the fuel cycle. Although not public due to the sensitivity of some information, this guide is instrumental in bridging the knowledge gap for SMR designers

When drawing up this guide, the Nuclear Security Authority faced several challenges:

* Explaining, in a concise and clear manner, the regulatory framework and main procedures;
* Explaining the principle of nuclear security and the integration of “security by design”;
* Orientating the operators towards technological choices requiring fewer security resources;
* Describing the principle of information protection;
* Explaining nuclear security strategy and performance demonstration based on the DBT to designers who don’t have security clearance;
* Advising how to design a nuclear security system;
* Explaining cyber security risks;
* Integrating the cycle of the combustible and the activity (upstream, transport, downstream).

The guide provides an explanation of French nuclear security principles, including a reminder of the components of nuclear security which are:

* Knowledge and monitoring of threats;
* Prevention and protection against insider threats;
* Protection of information, in particular of classified information;
* Computer security;
* Nuclear materials accounting and control;
* Physical protection;
* Installation design adapted to contribute to nuclear security;
* Management of malicious acts, in particular terrorist acts, including measures contributing to the recovery of illicitly removed nuclear materials of measures taken to limit the consequences of malicious acts;
* Nuclear security management;
* Nuclear security culture.

It includes the authorization procedure and features specific to nuclear material transport. The transport of nuclear materials requires special attention to security due to potential threats. It is often overlooked that these aspects must be taken into account. It is important to consider the security of these materials during SMR transportation to the user site, transport of fresh fuel, disposal of spent fuel, and even disposal of the SMR at the end of its life cycle.

The guide emphasizes the importance of incorporating security measures into all aspects of nuclear facilities, including technical, organizational, and human factors to comply with regulatory requirements.

Furthermore, the guide incorporates all the key points outlined in the subsequent section.

### Several key points learned

#### Security by design

The most important lesson learnt by the Nuclear Security Department concerns security from the design stage and during the whole life cycle of the reactor. It includes transport, reactor operation, waste storage, etc..

A big focus is made on the transport. Indeed, the transport of SMRs loaded with nuclear materials must adhere to stringent protection obligations and nuclear security objectives as outlined in the regulation. It is essential that design solutions minimize radiological consequences in the event of an attack on the transport vector and its load, mirroring the security considerations of the installation itself.

Moreover, given the evolving nature of threats, the national context may change over time. Therefore, designs must accommodate the possibility of adapting security measures to future national contexts, allowing for enhancements to basic security measures as necessary. It is crucial to anticipate changes in legislative and regulatory frameworks, as well as updates to the DBT, which may introduce new requirements in the future. Incorporating design margins for security features is vital. This foresight enables the enhancement of security measures throughout the SMR's lifespan, ensuring both immediate and long-term security success.

The Nuclear Security Authority has identified that security costs for SMRs are proportionally higher than for larger reactors. While current nuclear sites incur significant safety costs with moderate nuclear security expenses, SMRs may face substantial security costs if the design does not adequately address security requirements. High security costs could impede the viability of SMRs, making it essential for designers to consider nuclear security costs from the outset.

SMRs aim to offer an affordable alternative to traditional nuclear power plants while maintaining economic viability. Therefore, robust design is critical.

The economic model of SMRs should not rely solely on mass production but also on cost reduction through innovative design. Integrating nuclear security considerations early in the design phase can lead to significant cost savings by creating inherent solutions that synergize with other design concerns and optimize security provisions. This early integration allows developers to creatively meet nuclear security standards and invent new solutions.

All nuclear facilities, including SMRs, must fulfil the same requirements. By prioritizing "security by design," developers can ensure that SMRs remain both secure and economically feasible, addressing both current and future security challenges effectively.

#### Assessing the nuclear security stakes of the reactor, in order to identify the level of protection needed

French nuclear security regulation follows a graded approach, incorporating both prescriptive requirements for all nuclear facilities and performance-based requirements for high-risk installations.

Regarding theft, the guidelines reference the CPPNM and the categorization of nuclear material, employing a graded approach. French regulation utilizes the categories defined by the CPPNM and IAEA guidelines, including NSS13 (INFCIRC/225/Rev.5). However, the guidelines recommend using less sensitive materials, preferably Category II or III, whenever possible, to reduce the stakes and minimize nuclear security requirements.

Regarding sabotage, French regulations are proportional to the potential radiological consequences, in line with NSS13. If such consequences could reach High Radiological Consequences (HRCs), as defined in NSS13, the operator must perform a “performance demonstration”, which includes:

- Identifying targets (similar to identifying vital areas as defined in NSS13);

- Identifying sabotage scenarios, considering the capabilities of the Design Basis Threat (DBT);

- Justifying that the nuclear security measures are adequate to mitigate these scenarios.

The nuclear security measures required in this process are generally more stringent than those for situations with consequences below the HRC threshold. Therefore, the initial step in determining the necessary level of nuclear security is to assess whether an installation could result in consequences exceeding the HRCs.

The details of the HRCs and the DBT are classified on the basis of national defense security and cannot therefore be disclosed with designers. As a result, the French guide provides references to past terrorist attacks that designers can use to create their own DBT (“designer’s DBT”) for evaluation purposes. Additionally, it advises designing reactors to ensure radiological consequences remain below 50 mSv. This guidance enables operators to make a preliminary assessment of potential consequences.

Although the “designer's DBT” may differ from the French DBT, the French Nuclear security Authority, with the support of its Technical Support organization (IRSN), should have sufficient information to determine whether the reactor could cause consequences greater than the HRCs. Similarly, designers are not provided with the HRCs but are encouraged to use security by design to achieve consequences below 50 mSv. This offers practical guidance for designers on how security by design can assist them.

#### Computer security

Computer security is an increasingly critical concern across all business sectors.

For SMRs, several specific issues have already been identified, particularly regarding proposals for reactors with autonomous and remote control. The stakes are high, as a malicious act on a remote information system could significantly impact the reactor.

The guide provides a methodology for identifying the information systems that require protection and outlines the relevant regulations. It emphasizes the importance of protecting remote operations, such as remote maintenance, to raise awareness among designers at the earliest stages.

The DSN works in collaboration with ANSSI, the French national agency for information systems security, to coordinate these efforts. The French Nuclear Security Authority takes into account the safety analysis on remote control. If these studies confirm that the reactor design is safe and stable, a malicious act on the remote control should not have any significant consequences.

However, for remote monitoring tools used to ensure site security, the DSN stresses the importance of using secure and functional tools to maintain security of the site.

#### Information protection

Protecting information is crucial for nuclear security.

Malicious actors need detailed information about a facility's design to plan an attack, making information security a vital component. Effective information protection can act as a significant barrier against such threats.

Implementing security by design is a major challenge, as French regulation restricts access to classified information, including the DBT (Design Basis Threat), to companies and individuals identified as “important for the nation” and who have the proper security clearance. Obtaining this clearance can be a lengthy process.

To avoid administrative delays, the French Nuclear Security Authority promptly confirms with the designer whether access to classified or sensitive information is necessary. A memorandum of understanding, covering all aspects of information protection, is then signed with the designer.

In France, the Nuclear Security Authority is part of the Defense and Security Directorate, which also includes the Department of Economic Intelligence and Information Protection. This memorandum allows for the protection of both nuclear security information and industrial secrets, including information related to the scientific and technical heritage of designers.

Currently, the DBT can only be delivered to the future operator, not the designer, once a specific project (the reactor itself and all its environment and the location) has been identified. Additionally, the French DBT contains information that may not be required during the early design stage. This policy aims to prevent the unnecessary dissemination of classified information.

Therefore, the sharing of classified information is strictly managed on a need-to-know basis, with the French National authority providing only the necessary information to the designer at the appropriate time. Nevertheless, the issue of sharing the DBT with designers to account for reference threats in their design has arisen. The “need-to-know” principle can be extended to enhance security.

However, there is a risk that sharing the DBT with too many different parties undermines its purpose, as it becomes widely known. A good compromise shall be found and it is what the DSN has started to do with such a process.

### Cooperation with other authorities

Given that SMR development involves multiple authorizations and is crucial to French energy policy, the Nuclear Security Department has enhanced its collaboration with various government offices.

In France, different authorities oversee different aspects of nuclear regulation: the Nuclear security Department (DSN) that addresses security issues, the French Nuclear Safety Authority (ASN) that addresses safety issues, and the EURATOM Technical Committee (CTE) that addresses safeguards issues. Designers must ensure their measures comply with all three sets of regulations and avoid conflicts between them. While there can be positive synergies among these regulations, there are also risks of incompatibility.

Cooperation among authorities is essential for efficient processing and effective information sharing. Anticipating these interfaces allows designers to consider them early in the process and optimize their efforts.

Furthermore, the DSN has instituted semi-annual meetings with services of the ministries involved in the development of SMRs to address nuclear security at the highest level. This ensures that nuclear security considerations are integrated into the broader energy policy framework by key stakeholders. Nuclear security must be considered not only in the localization of SMRs but also in preparing response in case of an attack.

3. CONCLUSIONS AND PERSPECTIVES

In summary, while SMRs pose new challenges and demand extensive cooperation between all stakeholders, French regulation is sufficiently adaptable to accommodate these new technologies and sites. Ensuring the nuclear security of SMRs involves maintaining high standards and coordinating with various government authorities to adapt national security arrangements to this new paradigm.

Creating a guide and implementing a process to support SMR and AMR designers is vital for incorporating ”security by design” into their projects. Awareness of security issues is essential for the success of these projects due to the high stakes involved.

Notably, the radiological consequences of a malicious act on an SMR could be significantly reduced due to its design, leading to alternative protection requirements and reduced costs. The French Nuclear Security Authority supports designers in adopting this approach. Given the novel design and technology, and the fact that designers are not always operators, the French Nuclear Security Authority has developed new guidance and approaches.

The guide, distributed to designers in October 2023, has been well received, facilitating the understanding of French regulatory requirements and allowing designers integrating security aspects into their designs. However, there is room for improvement, including detailing the roles of other governmental actors in nuclear security and addressing administrative and technical safety/security interfaces.

Additional guidance on threat mitigation, such as cybersecurity, drones, and insider threats, could further enhance the guide.

Through this approach, the French Nuclear Security Authority aims to ensure that the nuclear security of SMRs meets the same requirements as existing nuclear sites.