

**ICEBERG : An Informatic Platform Processing Nuclear Material Accounting Data  
for French Non Proliferation Commitments**

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**Abstract:**

*A proper accounting system is among the pillars that structure the Euratom safeguards implementation. Accounting declarations from nuclear operators are also crucial for the preparation of the many reports required under France's nuclear non-proliferation commitments, to the European Commission, AIEA safeguards agreement or national regulation. Among its missions, IRSN (Institute for Radioprotection and Nuclear Safety), as technical support for CTE (Euratom Technical Committee, the French authorities' representative for Euratom) is responsible for managing and processing accounting data from operators for national and international declarations. In order to optimize the process of preparing these declarations and ensure long-term data storage, IRSN is currently developing a new informatic platform called ICEBERG (Intégration de la Comptabilité Euratom en Base pour l'Établissement des Rapports sur les Garanties). Partially funded by the French recovery plan, ICEBERG firstly consists of a module which integrates accounting declarations, both from national and international regulations, with syntactic and semantic controls. ICEBERG will also build numerous reports by aggregating data from both regulations, with respect to each report formalism and requirements. In order to simplify the analysis, the tool will automatically highlight discrepancies and major changes in each final report. Besides, a request module will allow the user to extract information from the databases. Overall, ICEBERG contributes to the reliability and durability of accounting declarations from French nuclear operators. The tool also allows for more efficient and secure reporting.*

*This paper presents the framework and objectives of the new ICEBERG tool. Then, its structure and the reflection around the management rules will be discussed.*

**Key words:** Euratom, France, TSO, accounting reports, informatic

## **1. Introduction**

Nuclear material accountancy is one of the fundamental safeguards measures, along with containment and surveillance. A proper accounting system means that nuclear operators monitor permanently the key information about their nuclear material (quality, quantity, obligation...). Accounting is also necessary in order to meet AIEA and Euratom requirements in terms of declarations.

For French authorities, gathering operators accounting data, at the state's scale, is essential for elaborating reports required under France's nuclear non-proliferation commitments, to the European Commission, AIEA safeguards agreement or national regulation. These declarations are very different from one another in regards of content and formalism, and are based on multiple data sources, including national accounting requirements. Over the course of one year, excluding the Additional Protocol declarations, a total of 34 accounting reports are prepared, including two monthly declarations, for both national and international authorities. Besides, as France is one of the most nuclearized country in the world, French operators' nuclear material accounting declarations represent a substantial amount of data.

Gathering accounting data and elaborating reports is one among various missions of the Non-Proliferation and Nuclear Material Accountancy Department (SNPC) of IRSN (Radioprotection and Nuclear Safety Institute). The Department is also the technical support organization that provides support to the French authority Euratom Technical Committee (CTE) in charge of monitoring the implementation of international treaties of nuclear non-proliferation. Within the SNPC, the nuclear material accountancy office (BCMn) oversees gathering operators accounting data, both for national and international regulations. Nuclear office (BN) aggregates and elaborates the different declarations, with respect to each report formalism and requirements. On a more punctual basis, national accounting databases allows SNPC to answer specific requests from various French authorities (Ministries of Foreign Affairs, Environment, Defense...).

Managing important amounts of sensitive data, such as accounting information, requires reliable, secure and scalable informatic tools, in a world where IT technologies evolve rapidly. Taking the opportunity of the French recovery plan funding, SNPC is currently developing a new informatic platform, presented in this paper. ICEBERG (Intégration de la Comptabilité Euratom en Base pour l'Etablissement des Rapports sur les Garanties) will optimize the process of preparing accounting declarations and ensure long-term data storage for accounting data.

First, the paper presents workflows and informatic tools currently in use, for both BN and BCMn offices. The next paragraph details ICEBERG's structure and how sustainability and adaptability are better ensured. Then, the data integration module and report elaboration module are explained. Finally, improvements expected using ICEBERG are presented.

## **2. Before ICEBERG: reliable but aging technologies and need for optimization**

Historically, BCMn and BN offices were in separate departments until quite recently, even though their missions are rather complementary. This explains why their workflows are entirely independent, while both teams daily communicate with each other. French national accounting features are better described in [1]. The next paragraphs detail each workflow with its objectives, informatic tools and current limitations.

## 2.1 Controlling and gathering accounting files

As illustrated on figure 1, BCMN agents oversee gathering operators' declarations, ensuring data compliance and integrity through semantic and syntax controls, and finally transmit operators' declarations to Euratom. According to Euratom regulation [1], monthly Inventory Change Report (ICR) are required at the latest 15 days after the end of the month (article 12), while Material Balance Report (MBR) and Physical Inventory List (PIL) must be sent 30 days after the physical inventory (article 13). As a result, BCMN Office receives and controls about 2500 .xml files a year.

Nuclear operators submit their documents on a secured platform. .xml files are then manually collected and entered into Nuclear Material Manager (GMN), which controls each file based on Euratom .xsd schemes. Syntactic verifications are performed (size of tags content, mandatory or optional state...). Semantic verifications are then carried out: tags content is compared with MBA information filled in GMN database. Every month, several .xml files are rejected after GMN controls, and the operator is kindly asked to send back a corrected document. As a result, very few .xml files from French operators are turned down by Euratom controls (about ten per year). BCMN agents also confront the number of received files with the MBA list entered in GMN, to follow up with potential latecomers. Finally, all the .xml files which successfully passed GMN controls are sent to Euratom. A copy is also transmitted to the BN Office, in charge of reporting elaboration.

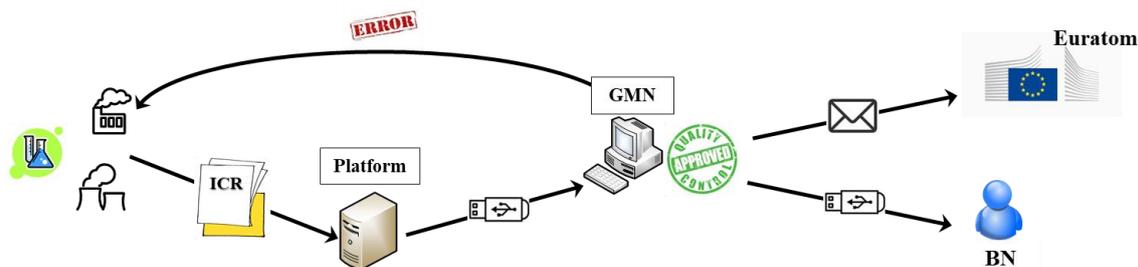


Figure 1 : BCMN current workflow for Euratom accounting files

## 2.2 Elaborating reports

French nuclear material declarations are based on national and international accounting data, not only for international entities but also national authorities. Those reports mainly consist in data tables of various sizes, but a single report can include up to a dozen separated spreadsheets. Figure 2 provides a non-exhaustive list of the main declarations elaborated every year.

GAUSS is BN's current computer application specially developed for data aggregation and report elaboration. It was first designed for elaborating the monthly declaration required within French safeguards agreement INFCIRC/290. Overtime, new reports were created, and some existing declarations evolved in their presentation and/or their content. GAUSS, with his pre-existing structure, was not necessarily adapted to take over their elaboration. Therefore, several declarations are currently entirely hand-crafted and, depending on their complexity, some can take up to two weeks of full-time work for one BN agent.

Report	Content	Frequency	Recipient	GAUSS elaborated
INFCIRC/290	Safeguard agreement between France, EURATOM and IAEA	Monthly	Euratom/AIEA	Entirely
INFCIRC/415	Voluntary information on production inventories and international transfer of thorium and uranium concentrates	Monthly	AIEA	Entirely
France/Japan	Bilateral nuclear cooperation agreement	Annual	Japan	Entirely
INFCIRC/549	Voluntary information on plutonium inventories	Annual	AIEA	Partially
Enriched Uranium Transparency	Voluntary information on highly enriched uranium	Annual	AIEA	Partially
France/Australia	Bilateral nuclear cooperation agreement	Annual	Australia	No
Flux & Stocks	Internal report	Annual	French authority	No

Figure 2 : Main reports elaborated by BN agents for French Non-Proliferation Commitments

GAUSS, whose functioning is also described in [3], was developed in .NET language coupled with the Microsoft SQL Server suite for data aggregation and reporting. Several inputs files from different sources are needed: ICR files of course, but also specific documents in Excel format, from national accountancy database, provided by BCMN. As a result, BN agents often spend a significant amount of time, with the help of BCMN, ensuring input data completeness before manually entering files in GAUSS.

Report development also requires key MBA information (type, fuel cycle step, company...), provided by an additional program called ZEST. GAUSS organizes and aggregates accounting information into data tables, using Extract Transform Load (ETL) technology. Reports are then generated in Excel format through SQL Server Reporting Services (SSRS).

GAUSS is also equipped with a request module, widely used for verification and analysis purposes. Its database, supplied every month with new information, allows complex requests over 15 years of accounting data. Figure 3 illustrates the workflow applied for most reports.

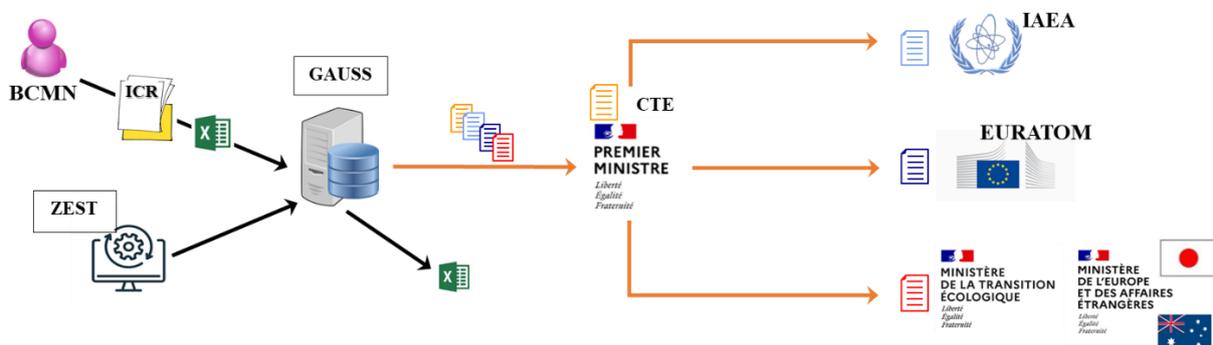


Figure 3 : BN current workflow for elaboration of most accounting reports

Whether or not they are generated through Gauss, all declarations require at least a few manual interventions to be completed. Cross-checked verifications are then conducted to ensure reports integrity. Finally, BN agents devote time to data analysis, comparing the new report with those previously prepared. At this stage, GAUSS query tool is abundantly used.

### **2.3 Limitations and need for a new standalone IT platform**

This operating method has proven to be reliable. However, many flaws can be pointed out, leading to the creation of a new IT platform:

- Both BN and BCMN workflows require numerous manual interventions and multiple keeping-up-to-date of the same information in different databases, which is not suitable for long-term storage and sustainability.
- The current chain of accounting data managing and report elaboration involves several informatic tools, with independent structures and separated databases, which leads to unnecessary data storage multiplication.
- Various report inputs require multiple entry sources in different data formats, with heterogenous control levels, which could be optimized.
- MBA information are unnecessarily repeated in separated tools, while they could be centralized in a unique platform and database.
- Since GAUSS does not complete all reporting steps, BN analysts spend a substantial amount of time on tasks that could easily be automated.
- Verification process of accounting reports currently implies a lot of manual operations that can be automated and rationalized.
- Finally, BN and BCMN offices, while manipulating the same information, do not have a shared platform which would really facilitate communication and simplify the interface between their missions.

The update suggestions listed above necessitate more than just an upgrade of existing tools. Notably, GAUSS's operating system will be obsolete before long and will not be able to keep up with WINDOWS operating system upgrades and network's security requirements. Overall, while SNPC informatic programs could still live on for a while, it is important to consider the time required to develop a new tool from scratch.

With GAUSS announced obsolescence, the need for optimization and the many operations done manually that could be done automatically. Thanks to the help of the French recovery plan (State economic support for selected companies with an accent on digital transformation), SNPC agents reflected on an IT platform integrating all the functionalities presented above, from .xml files control and integration to reports elaboration, including a comparison module and the query tool. The structure of this new platform, called ICEBERG, is presented in the next section.

### **3. ICEBERG global structure**

As shown on Figure 4, ICEBERG's operational architecture is separated in two main blocks: the data warehouse and aggregation structure in blue, and the web Human Machine Interface (HMI) in green.

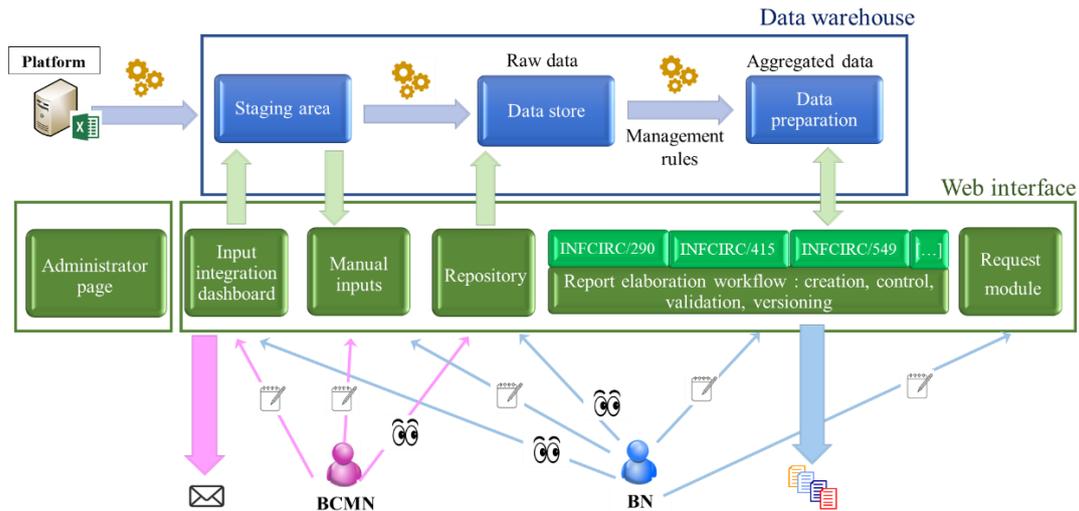


Figure 4 : ICEBERG structure

.xml files submitted on operators' platform are automatically imported and controlled before being integrated in the data warehouse. The data warehouse stores both the staged data (raw data) and the aggregated data according to reports management rules. The data warehouse uses PostgreSQL database management system and is fed by an ETL tool (Talend), represented here with cogwheels.

The HMI is a PHP web platform generated using Symfony framework. ICEBERG users are divided into three groups: administrators, BCMN profile (in pink) and BN profile (in blue). Apart from the administrator page, ICEBERG's interface presents five modules: repository, inputs, reports, query tool and comparison module.

First, the repository includes all relevant MBA information, but also regulation tables and all information necessary for reports elaboration. All users can access the repository but only administrators can update information.

While .xml files are directly imported into the data warehouse, separate Excel files and very specific information are entered using a manual inputs menu linked to a repository monitored by the ETL tool. The dynamic input integration dashboard is available for all users.

While based on very different management rules, all reports follow the same workflow, detailed in section 5. Reports can be consulted within the web platform using Jasper and can also be extracted in various formats (.pdf, .xlsx, .xml).

The request module interrogates the data store for any input data. Customizable data masks allow a wide variety of uses and outputs.

Finally, the comparison module (not displayed on Figure 4) will automatically compare two reports from two selected periods of time. The main differences will be highlighted, based on selected criteria, which will facilitate the user's analysis work.

Unlike GAUSS, ICEBERG's structure is designed to remain flexible in case of report elaboration changes thanks to the data repository management function. Most updates would no longer require any complex code intervention, but a simple correction in the data repository from an administrator. Moreover, the tool is built with transparency in mind: all the tables on which the reports are based are accessible to the users, at least in consultation. Reports, while relying on input data and sharing the same workflow, are completely independent from one another. Depending on their evolution, one can be deleted or another can be developed without disturbing the tool.

Overall, ICEBERG is a modern standalone platform, meeting both BN's and BCMN's needs. Section 4 describes inputs control and organization before illustrating how BCMN agents will perform accounting data control and integration using ICEBERG. In section 5, BN reports elaboration is explained.

## **4. Integration and management of accounting data in ICEBERG**

### **4.1 ICEBERG inputs data**

As seen on Figure 4, ICEBERG inputs data come from three main canals: automatically imported files (Excel and .xml), manual inputs and the repository.

.xml input files integration remains quite similar to GAUSS's process, while syntactic and semantic controls were taken from GMN. However, a few .xml files, out of the 2500 sent every year, still passed GMN controls and were rejected by Euratom. The missing controls are added in ICEBERG. In addition, ICEBERG cross-checks .xml files against the MBA data repository: every open MBA is requested to send an ICR every month, and a MBR and PIL every year. Additional rules also ensure that inventory ICRs are also correctly filled in.

.csv files will be generated and submitted by BCMN agents. A particular effort was made to homogenize files content to allow for automatic import. While they were directly integrated in GAUSS without any check, in ICEBERG every line is compared to regulation tables (obligation among others), as well as the MBA data repository. When possible, .csv files are cross-checked with ICR data, ensuring consistency.

Specific details are not available in any accounting input and are solely based on user knowledge. That is why, for very specific and well-defined cases, users can manually complete particulars. Even then, ICEBERG cross-checks every user entry and limits possibilities using the data repository. For example, the user doesn't type the name of an MBA but chooses from a drop-down menu. ICEBERG report workflow is designed so that manual information can always be corrected and the changes historized.

The last inputs source is the data repository, which is one of ICEBERG's pillars. Prior to ICEBERG's development, each report was deconstructed to list all the necessary information missing from input files. First, details for each MBA are gathered in one "identity card", mentioning more than 15 different characteristics for each of them. Articulation between MBAs from the same installation, site or company is also taken into account. Other regulation guidance, such as obligation codes, country codes list or inventory change codes is also integrated and available for consultation.

### **4.2 ICEBERG accounting data integration workflow**

As detailed in section 1, in France, BCMN agents currently gather manually all ICRs from nuclear operators, control the files through GMN, possibly ask for corrections then send the declarations to Euratom, all within the course of a few days.

With ICEBERG, integration and controls will take place automatically. BCMN agents will be able to consult ICEBERG dashboard, shown on Figure 5. Files will arrive one by one and will

be integrated in ICEBERG within 15 minutes of their arrival on the exchange platform. Files with errors would appear in the red boxes below, BCMN user will be able to access a short but explicit message explaining the reason for file rejection. If needed, rejected files can be downloaded. Once all the expected files arrived, BCMN agents will generate a .zip ready for sending to Euratom.

The dashboard also shows an annual .xml file counter and the integration state for .csv files, both for BN and BCMN users.

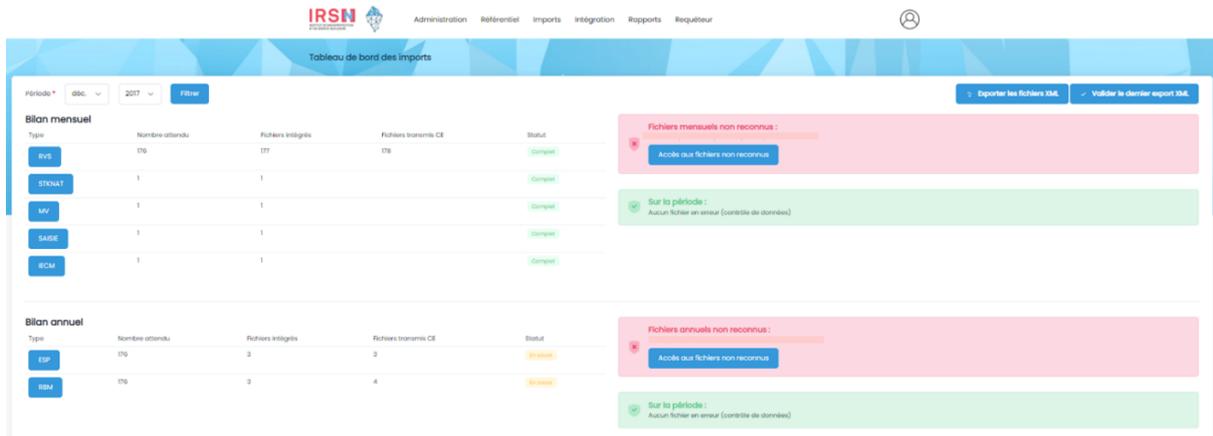


Figure 5 : ICEBERG dashboard for integration

## 5. Data aggregation, reports production and analysis tools

ICEBERG outputs include not only accounting reports for various authorities, but also two modules highly valuable in assisting BN agents in the analysis or monitoring of nuclear materials: the request module and the comparison module.

### 5.1 Management rules and data aggregation

Before developing ICEBERG, all reports were examined from all sides and hand-crafted at least once, in order to break down declarations into clear and sensible steps. For each of them, input accounting data and repository requirements were thoroughly listed. Most of declarations display basic information, such as nuclear material masses, categories or obligation. However, the way of aggregating the masses, of organizing the presentation (by fuel cycle stage, by country, by operator...) makes each report a unique element, with specific management rules.

ICEBERG produces mainly Excel spreadsheets, with respect for data aggregating but also data presentation. Terminology and formalism vary depending on authority requirements, which is considered through the many MBA characteristics in the data repository. For especially large reports, ICEBERG not only produces final products, but also working tables with intermediate data aggregation, in order to help the user on the analysis. Likewise, ICEBERG produces a few graphs.

### 5.2 ICEBERG report elaboration workflow

ICEBERG report elaboration workflow is designed to operate for each declaration. With input data arriving little by little, BN user can consult the building report but not export it. Once all necessary input data are successfully imported, the report becomes available for the BN user to thoroughly study the data. Once satisfied, the user transfers the report to the supervisor for

double check and validation. If a mistake is spotted, the supervisor can send back the report to the BN agent for correction. Once the report is validated both by the BN agent and the supervisor, the report is marked as finalized and can be sent to the corresponding authority.

If a new input file altering the report content is integrated in ICEBERG (for example a latecomer ICR file), a new version of the impacted report becomes available, while the previous versions can still be consulted. This system allows a permanent consistency between the database and the generated reports.

Likewise, if one report relies on manual inputs, it becomes available only after the user completed the required details. If the user wants to go back on the information entered, ICEBERG will generate a new version of the report, while the previous one will still be available for consultation.

### **5.3 Analysis : ICEBERG query tool and comparison module**

GAUSS query tool is used daily by BN agents, not only for accounting reports. Among their missions as technical support organization for French authority CTE, BN agents assist French operators with regulation requirements, which demands the ability to query the ICR database at any time. ICEBERG query tool does not only cover for GAUSS's but it will also allow users to visit databases from other input files, including .csv files from national database. Crossing input databases is not discussed at the moment.

The comparison module will later be developed once all reports are completed. For most declarations, BN agents study the nuclear material fluctuations compared to the previous version of the report. This analysis work is preceded by several manual operations compulsory to highlight the main variations within the data. ICEBERG will prepare and put data into shape by bringing out differences above a user-determined threshold. Other control and comparison elements are also considered, such as trends over longer periods of time, or statistics.

## **6. ICEBERG development and foreseen improvements**

### **6.1 ICEBERG schedule and development**

The ICEBERG project began in early 2021 with the reflection around the repository, coupled with management rules elaboration. Informatic projects of this magnitude are sometimes spread over the course of several years, but thanks to the French recovery plan funding, SNPC could consider an intensive development in agile mode over approximately 18 months.

ICEBERG teams within IRSN consists in two BN agents, assisted with one project owner support. The development team amounts to two full time programmers, one expert available if needed, and one project leader.

ICEBERG development officially started in April 2022. At the time of writing this article, ICEBERG data repository is completed, and three years of data were successfully imported. Two declarations are finished, five others are in the testing phase and one is currently being programmed. The design of the comparison module, as well as the loading of 15 years of accounting data, will start during the summer. The tool will enter the production phase during autumn 2023.

## 6.2 Foreseen improvements

ICEBERG's arrival will change work habits for BCMN and BN agents regarding accounting data integration and reports elaboration.

First, many previously manual operations will be automated, which highly enhances data quality and integrity, but also free up a substantial amount of working time. Likewise, gathering functionalities and data from three independent tools into one unique platform will limit data storage multiplication and improve long-term storage and sustainability. Overall, homogenizing input files, as well as centralizing data storage through the data repository guarantees a better durability and ability to evolve.

For BN users, while the impact on reports already fully generated with GAUSS is rather limited, significant time saving can be looked forward to, especially for substantial annual reports with many outputs and complex management rules.

In a broader perspective, ICEBERG will provide access to so far sleeping or hard to reach databases, for input files but also reports. This new platform opens up horizons for data analysis and monitoring the evolution of French nuclear material flows and stocks.

## 7. Conclusion

In order to meet France's nuclear non-proliferation commitments, SNPC agents oversee gathering operators accounting data, from national and international regulation requirements, then aggregate and elaborate the numerous reports required under French non-proliferation commitments, with respect to each report formalism and management rules. Several software tools were developed over time to assist agents in those mission. While current tools have proven to be reliable, fast changing technologies, lack of adaptability, security requirements and need for optimization called for the creation of a brand-new IT platform called ICEBERG. The tool is built with a view to adaptability, transparency and process optimizing. It contains a complete and standalone repository and automatically controls and imports inputs files. Integrating accounting data will no longer require manual operations. Report elaboration, based on comprehensive management rules, will be fully automated with a workflow taking into account corrections and manual inputs. Moreover, analysis tools, such as request and comparison module will also save agents a substantial amount of time. Overall, ICEBERG contributes to the reliability and durability of accounting declarations from French nuclear operators.

## 8. References

- [1] BON NGUYEN R., French centralized nuclear material accounting: a tool at the heart of national security and safeguards implementation, INMM & ESARDA Joint Annual Meeting, 2023
- [2] Commission Regulation (Euratom) No 302/2005 of 8 February 2005 on the application of Euratom safeguards - Council/Commission statement
- [3] DEBRUYNE M., DECROOCQ C., "Digital Tools for Safeguards: The French TSO's Point Of View", INMM & ESARDA Joint Virtual Annual Meeting, 2021