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**Report on Strengths, Weaknesses and Optimization of Decommissioning Planning Information Mode**

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Authors : Mr. Nicolas DELANNAY (ENGIE), Emma Peltonen (VTT), Bérange Clère (Cyclife DS), Dusan Daniska (WAI), John Einar Hulsund (IFE), Yann Kerhof (CEA), Patrice Francois (IRSN)

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Author(s)	Mr. Nicolas DELANNAY, Emma Peltonen (VTT), Bérangère Clère (Cyclife DS), Dusan Daniska (WAI), John Einar Hulsund (IFE), Yann Kerhof (CEA), Patrice Francois (IRSN)
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### Summary

Deliverable D4.2 formalizes the feedback on the approach proposed in PLEIADES, i.e. the use of a platform centralizing the data of a nuclear D&D project, and the interoperability with this platform of multiple applications. The evaluations are transcribed in terms of strengths and weaknesses (or suggestions for improvement) of the proposed solution, as well as how to optimize D&D tasks with the use of the platform. Also, a discussion is provided on the points that could have been improved in the different tasks of WP1 to WP3.

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### Approval

Date	By
2023-12-07 16:24:27	Dr. Markus AIRILA (VTT)
2023-12-08 12:03:44	Mrs. Marie-benedicte JACQUES (CEA)

# PLEIADES project

## WP4: Modelling and results evaluation

### D4.2: Report on Strengths, Weaknesses and Optimization of Decommissioning Planning Information Models

(M34, Tractebel, R, PU)

**Lead authors:** Nicolas DELANNAY<sup>6</sup>, Mathieu POMAREL<sup>1</sup>

**Co-authors:** Emma Peltonen<sup>9</sup>, Bérangère Clère<sup>1</sup>, Dušan Daniška<sup>2</sup>,

John Einar Hulsund<sup>3</sup>, Yann Kerhof<sup>4</sup>, Patrice Francois<sup>5</sup>,

**Other contributors:** J. A. Ridao Cabrerizo<sup>7</sup>, Maarten Becker<sup>8</sup>, David Murigneux<sup>10</sup>, Fco. Javier Domínguez Casals<sup>11</sup>, Alexandre Avenel<sup>12</sup>, Antoine Lasnier<sup>12</sup>, Paul Tamayo-Serrano<sup>4</sup>, Robin Thomas<sup>6</sup>, Tapani Rynänen<sup>9</sup>, Mika Hakkarainen<sup>9</sup>, Mikael Uimonen<sup>9</sup>, Juri Mattila<sup>9</sup>

**Reviewer:** Markus Airila<sup>9</sup>

<sup>1</sup> Cyclife Digital Solutions – France

<sup>2</sup> WAI s.r.o. - Slovakia

<sup>3</sup> Institute for Energy Technology - Norway

<sup>3</sup> French Alternative Energies and Atomic Energy Commission - France

<sup>5</sup> Institut de radioprotection et de sûreté nucléaire – France

<sup>6</sup> TRACTEBEL (Engie) – Belgium

<sup>7</sup> Karlsruhe Institute of Technology - Germany

<sup>8</sup> Institut für Umwelttechnologien und Strahlenschutz GmbH – Germany

<sup>9</sup> VTT Technical Research Centre of Finland – Finland

<sup>10</sup> Électricité de France (EDF) – France

<sup>11</sup> Empresa Nacional de Residuos Radiactivos, SA – Spain

<sup>12</sup> LS Group – France



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## Keywords

Nuclear, Decommissioning, Platform, Digital Tools, Data, Databases



## Glossary

Abbreviation / acronym	Description
ALARA	As Low as Reasonably Achievable
API	Application Programming Interface
BCOT	EDF facility “Base Chaude Opérationnelle du Tricastin”
BIM	Building Information Modelling/Management
CDE	Common Data Environment
D	Deliverable
D&D	Decommissioning and Dismantling
HRR	IFE facility “Halden Research Reactor”
IFC	Industry Foundation Classes, a data model intended to describe architectural, building and construction industry data
IT	Information Technology
JSON	JavaScript Object Notation, an open data interchange format that is both human and machine-readable
LOD	Level of Detail
NPP	Nuclear Power Plant
OECD	Organization for Economic Cooperation and Development
PLM	Product Lifecycle Management
SMG	ENRESA facility “Santa Maria de Garoña”
SSCs	Structures, Systems and Components
SW	Software
T	Task
TSO	Technical Support Organisation
US	User Story, particular study case for the use of the PLEIADES platform, performed within WP3
WP	Work Package

## Executive Summary

As we approach the end of the PLEIADES project, it is important and healthy to ask what has been achieved, and to assess whether it meets the initial objectives. This step can be seen as the "Check" phase of the Deming wheel.

The improvements or suggestions identified will allow to continue the development of the platform, and to see more clearly its positioning in relation to a future commercial exploitation.

In this context, the D4.1 deliverable, carried out in parallel with this one, concerns the process of collecting feedbacks and the efforts necessary to gather the data to work on the user stories (in WP3).

Deliverable D4.2 formalizes the feedback on the approach proposed in PLEIADES, i.e. the use of a platform centralizing the data of a nuclear D&D project, and the interoperability with this platform of multiple applications. The evaluations are transcribed in terms of strengths and weaknesses (or suggestions for improvement) of the proposed solution, as well as how to optimize D&D tasks with the use of the platform. Also, a discussion is provided on the points that could have been improved in the different tasks of WP1 to WP3.

Many comments were made and are reflected in the document. The main messages are as follows:

- The approach implemented through the platform and connected tools already covers a large number of studies and management activities of a nuclear D&D project.
- The partners believe that the main resistance to adopting the platform is more psychological than technical. It's not easy to change your work habits, and integrating methods into a data-centric process requires a change in mindset.
- Ways to make the use of the platform more easily accessible are:
  - o Set up examples and learning materials;
  - o Have user manuals directly accessible in the interfaces, and be able to support users;
  - o Enable the adoption of the system in a phased manner, by providing tools to transfer data, or by focusing the use of the platform first on certain studies only.
- The majority of partners also believe that the solution could be even more attractive with the interconnection of additional applications. In the future, we should seek to encourage this possibility of increasing the constellation of applications that can be connected to the platform. To move in this direction, the open-source distribution of the API and class definitions has been identified as a necessary step.
- From an implementation point of view, users consider that the proposed solution and the ontology put in place meet the needs identified at the outset. The use cases have been demonstrated in the framework of WP3. It will of course be necessary to set up a process to complete/adapt the ontology and data classes in the future.
- Many aspects can be further developed, and some features not yet implemented will be indispensable in the nuclear context (such as a stricter/secure data access policy). The elements to be developed as a priority will depend on which "business case" is being targeted at first.
- From the point of view of the user interface and the API set up to develop the connectors, here too the partners rate the solution as suitable and fulfilling the main needs well.

# 1. Introduction

## 1.1. Purpose

The main objective of WP4 is to analyse and evaluate the results obtained in WP 1, 2 and 3.

In short, WP1 defined the requirements and the needed ontology for managing the activities involved in the Decommissioning and Dismantling (D&D) of nuclear facilities. WP2 made the implementation of the PLEIADES platform, setting up a Common Data Environment, browser interface and API connectivity through which the different software tools of the partners could exchange information. WP3 performed the testing of the PLEIADES platform through the analysis of representative “user stories” for D&D projects. For this purpose, the data provided for three real nuclear facilities could be used (HRR, SMG, BCOT, with data collection and elaboration of 3D and BIM models performed through tasks 3.1, 3.2 and 3.3).

The outcome of this evaluation is formalized in the deliverables D4.1 and D4.2.

The focus of deliverable D4.1 is on the process and efforts needed for gathering the input data to perform the modelling and calculations showcased in WP3 (e.g., work plan and schedule, waste estimates, dose estimates and cost estimates).

It is also in deliverable D4.1 that the whole evaluation process is described, making use of questionnaires and interviews to gather the feedbacks from partners that were involved in WP1 to 3.

Here, in deliverable D4.2, the goal is to formalize the feedback regarding:

- The BIM approach for D&D projects and the solution implemented through the PLEIADES platform. Strengths and weaknesses (or limitations) of the approach as identified by the partners when implementing their connectors to the platform and performing their modelling analysis in WP3 are discussed. Additional insight is provided through industry experience and expert knowledge of the partners.
- Potential improvements or optimizations to the approach and the PLEIADES platform.

At the end, these feedbacks are informative to know how to orientate the future development, and how close (or far) we are from a viable commercial solution. In this respect, this deliverable is also supporting the reflection conducted within Task 5.4 “Exploitation strategy” and Task 5.7 “Preparation of a legal entity toward commercialisation of the PLEIADES platform services”.

## 1.2. Methodology

The work within PLEIADES project was structured somewhat like the Deming cycle with “Plan-Do-Check-Act” steps:

- WP1 corresponds to the “Plan” step: *“Analyse the current situation, identify the problem or opportunity, and plan a solution or improvement”*.
- WP2 and WP3 correspond to the “Do” step: *“Implement the solution or improvement on a small scale and collect data on the results”*.
- With WP4, we are in the “Check” step: *“Analyse the data, compare the results with the expected outcomes, and identify any gaps or errors”*.

- “Act” step: “Based on the analysis, either standardize the solution or improvement, or revise the plan and repeat the cycle”. This step corresponds to the positioning of PLEIADES platform for further development or exploitation discussed in WP5.

As mentioned above, for WP4, the methodology to evaluate the work and identify improvements (“Check” step) consists in covering all relevant aspects of the approach through a list of questions and collecting the feedbacks from partners in the form of surveys, interviews, and a workshop during the last plenary meeting. The questions are more relevant for those who have actually worked with the PLEIADES platform, but expert knowledge and industrial experience to support the feedbacks is also very valuable.

The process for collecting the feedbacks is described in more details in deliverable D4.1.

It should be noted that the evaluation of the overall approach is mainly coming from qualitative judgement and user’s experience. Indeed, it is not possible to have quantitative evaluation matrix that would be relevant for the large spectrum of D&D activities manageable through the PLEIADES platform. This is particularly true when there is no “base solution” to which the BIM approach in PLEIADES can be compared. The goal is to formalize the feedbacks expressed as well as possible.

### 1.3. Contributing partners

The list of partners involved in the tasks of WP4 is provided in Table 1.

Partner	Activity
Cyclife DS	Lead for task 4.3 related to the optimization of the global PLEIADES approach. Providing technical advice on the most critical attributes affecting decommission planning to inform the optimization effort. Options evaluation to optimize use of the PLEIADES approach
CEA	Assistance to evaluation of strengths and weaknesses with internal D&D experts Options evaluation to optimize use of the PLEIADES approach
KIT	Support for the identification of strengths and weaknesses
IFE	Using the research network of IFE and events related to the topic of this project organized by IFE for acquiring and analysing expert feedback for the system and concept to be developed in this project. Providing technical advice on the most critical attributes affecting decommission planning to inform the optimization effort.
IRSN	Check if required inputs data are relevant to support safety analysis development and are appropriate to be used with safety verification codes and software
iUS	Support for the identification of strengths, practical usability check and weaknesses, comparison to classic approach.
VTT	Lead for task 4.1 and deliverable D4.1. Implementation of data collection for evaluation (questionnaire, interviews) and analysis.
LS	Support for the identification of strengths and weaknesses
EDF	Support for the identification of strengths and weaknesses
WAI	Support for the identification of strengths and weaknesses
TRACTEBEL	Lead for the task 4.2 and deliverable D4.2. Support for the identification of strengths, practical usability check and weaknesses, comparison to classic approach.



	Providing technical advice on the most critical attributes affecting decommission planning to inform the optimization effort.
CATENDA	-

**Table 1. Partners contribution to task 4.1, 4.2 and 4.3**

## 1.4. Connections with other activities in the project

### Input:

- Task 4.1: it is within task 4.1 that the feedback of partners on the achievements of the Work Packages (WP) 1, 2 and 3 is collected. The feedback is the main input for the writing of this deliverable.
- WP1, WP2, WP3: as the goal of this deliverable is to assess the work performed in those two work packages.

### Output:

- The output of this deliverable is not directly used within other tasks of the project as it comes at the very end of the project. Nevertheless, the assessment formalized in this deliverable should help identify the viability of the PLEIADES platform for future exploitation, and paths of development that were identified by the partners. In this sense, it is connected to tasks 5.4 and 5.7.

## 2. Strengths and weaknesses of modelling approach

The objective of this paragraph is to highlight the strengths and weaknesses of the approach proposed through the PLEIADES platform. The analysis formalizes and complements the feedback received by the partners (the process used for collecting the feedback is described in deliverable D4.1).

The terms “suggestions” and “additional needs” are used instead of “weaknesses” as they relay the constructive and forward-looking spirit of the evaluation process. Identification of these suggestions and additional needs is very important as they provide insight on how to continue the development from the current state of the platform.

The analysis is organized from different perspectives to structure the ideas. There are of course some common features between the perspectives, as discussed in the text.

### 2.1. D&D work processes management through interoperable applications

In this section, the viewpoint is the end objective of PLEIADES, i.e., to enhance the D&D processes, improve the efficiency of performing the involved activities. We evaluate how the proposal platform with interoperable applications can help achieve this objective.

#### 2.1.1. Introductory comment

One of the starting points for providing an evaluation of the PLEIADES approach is to define what is the “present method” to which it must be compared. The answers received from the partners are the following:

- It is in fact difficult to define a “present method” because there are not so many past experiences of D&D projects, and the current D&D activities include often some first-of-a-kind aspects.
- The D&D studies are performed based on historical documentation (under various standard format: pdf, word, Excel...) and applications that do not necessarily match. It is not necessarily easy to recover the info or exchange it between different users. In this sense, the “present method” is in general a more “document centric” approach: the data is referenced through documents. With such approach, the difficulty is to ensure the coherence of data between all usages. In particular, with evolving data (updated as new information is acquired), it is not easily reported everywhere in the document chains.
- Part of the D&D activities could possibly be managed through PLM (product lifecycle management) software. There is not that much experience with those applications for D&D within the partners.
- Often, the historical work process relied more on manual data collection, while more automated process is possible today.

However, digitalization is everywhere. The importance of data collecting and exchange is taking an ever-increasing importance in our human activities. This is why we are shifting more and more towards a “Data centric” paradigms. In this paradigm, data is considered as the root of all processes, and the

stress is put on its accessibility and validation from the very beginning. This is linked to the concept of “single source of truth”, helping maintaining consistency between all processes.

Within this data centric paradigm, there is a need for IT infrastructure that can manage the data, and applications that can exchange and process it. The PLEIADES platform offers a solution to this need.

Another important point to keep in mind is that the requirements regarding the information stored and exchanged through the platform will greatly vary along the duration of the D&D of a nuclear facility. At the early stage of a project, the objective is to start with coarse estimates of the planning and costs of the whole project. For this purpose, we do not need to rely on very accurate 3D models and radiological data characterization. Making global estimates and assessing what assumptions have the highest influence on the results generally requires preliminary data and a good understanding of where bottlenecks could appear. The needs on the data and the platform will evolve from these initial global estimates, as the main strategic choices for the D&D project are made and as it is needed to go further in the evaluation.

Later in the D&D preparation, it is necessary to study more detailed scenarios, e.g., for the dismantling of large components or preparing remediation activities. At this stage, the information in the platform on the geometry, weights of components, radiological characterization, etc. of the facility inventory needs to be more exhaustive to assess properly the risks and select the appropriate dismantling techniques. Similarly, to the concept of “Level of Development” for a BIM model, the requirements regarding data accuracy will increase as we get closer to the actual dismantling phase. As a general rule, the “level of development” of the information in the database should be on par with the usage. A higher accuracy / development is required for the information that dominates the costs or the risks (e.g., the assessment of radioactive waste quantities that have to be sent to one of the waste repositories).

Work preparation will in general generate virtual data linked to the prospective outcome of the planned activity (e.g., the dismantling of a particular equipment will occupy the planning for so many days and generate that amount of secondary waste). A way to distinguish through the database between a virtual “future” data with a real “present” data is needed to avoid confusion.

Once the work is performed and the configuration of the nuclear facility is really evolving, the database will acquire the role of tracking changes, and being able to locate material in their different waste processing steps, until they are packaged and authorized to leave the facility. This is again a very different usage of the platform, with again specific requirements.

Within the PLEIADES project, it was not possible to perform all kinds of studies for each stage of a D&D project. The accent was put on performing detailed preparation studies for the main activities: obtaining radiological measurement on site, dismantling a large equipment, planning work for surface remediation within a room, assessing risks of work activities, assessing their costs and the waste produced.

### 2.1.2. Strengths

The main strengths of the PLEIADES platform identified by the partners are:

- Proposing some kind of standardization for managing D&D projects;
- Bringing different users together through the platform, allowing sharing and communication. This can help talking the objectives as a group rather than a sum of individual needs;

- Making it possible to access the information from everywhere once it is centralized;
- The possibility to put more streamlined processes in place.
- The possibility to review working activities planned with the support of visualization (3D models, but also images, drawings, etc.) greatly helps understanding the problem and identify potential risks. Being able to access all the material through the platform is a real advantage.
- The modularity of the platform, making it possible to add additional tools as needed by implementing a BIM database connector for the tool.

The overall result from the work on WP3 user stories is that the PLEIADES platform is an adequate solution for the purpose of managing many D&D activities. Of course, we can think at improvements (discussed below), but the minimum requirements to perform the demonstration of the concept have been achieved.

### 2.1.3. Suggestions, additional needs

The partners identified the following suggestions and needs:

- The “data centric” approach presents other kinds of difficulty to ensure that a user relies on the correct information. In this sense, document centric approach presents the advantage that the data is enclosed in a package (the document in which it is referred), and that this package can be self-sustaining when it provides the scope and justification for which the data can be used. In this regard, it could be interesting to be able to automate the generation of reports from the database. From the perspective of an independent reviewer, it is easier to provide a review of a report than review a database where the information is scattered.
- There is a difficulty to convert from an existing working framework. There is always a barrier to change the mindset. Even if we can see strong similarities between the old and the new framework, it can be difficult to reach a perfect match between both (i.e., being able to do exactly the same as what was done previously). It would help if adopting the new working framework could be done through smaller steps (e.g., filling data in an excel files is something people can do easily, then importing the content of the excel file to the database is something that is a bit more involved).
- Development of a workflow for each PLEIADES database was suggested, to enable tool users to exchange information with the data referent for the project concerned. To request additional data, clarification of existing data in the databases, etc.
- Development of a validation process for uploading new data to the database was suggested. For example, that the user of a tool submits his data to the database manager, and that it must then be validated before being accessible by other. Also, a kind of dashboard could be used to inform on the newly added data (or making use of notifications to client users).

It is to be noted that the strategic D&D choices that will orientate all activities are made in general during the earlier stages of the D&D project, when global costs, risks, planning estimates have been conducted. For example, should new support systems be installed, or should the existing ones be adapted to the dismantling needs, should the treatment be realized on site, or waste transferred to a dedicated treatment facility elsewhere, should dismantling start as soon as possible, or be delayed by some period, etc. It was not the focus of the study cases in WP3. We cannot be sure that PLEIADES platform would help in making those strategic choices.

#### 2.1.4. Other observations

The following “neutral observations” were also made regarding the work processes through the PLEIADES platform:

- A few applications were not yet tested with the platform, while they may play an important role for D&D work processes:
  - Augmented reality, for on-site training;
  - Connection with online real time data acquisition system;
  - Connector to automatically locate and give activity of hotspots;
  - Connector for remote operation of a robot in an area where a human cannot go. The robot could measure radiation levels in advance, and have the database filled in automatically as the work is performed.
  - Logistics application for following material / waste streams, keeping track of space availabilities in buffer storage and of waste packages until they leave the facility. We have in mind some management of package streams through QR codes put on each package; they are scanned at the exit of some storage place location and then knowing where this package is going. This information should be sent to the platform to update the status.
  - Connecting applications used in the decommissioning outside of the nuclear sector would be also very informative to know if the PLEIADES platform can target other sectors.
  - In the project proposal it was suggested to have a work-planning tool as part of the PLEIADES platform. Such a tool was never introduced in the project but could have made it easier to generate work order data.
- One of the objectives of the PLEIADES project was to demonstrate the use of the platform for optimizing some of the D&D work activities. To some extent, this could be achieved in the WP3 user stories by comparing different hypotheses for a particular work activity. However, at this stage, it was achieved through a kind of “trial-and-error” process. No guidance was provided to optimize a work activity. It is also noted that simulated scenarios are often highly constrained in the reality, in term of resources (e.g., a single equipment available to perform the work), potential solution (e.g. only one evacuation route possible for a particular component), planning (e.g. sequence of activity that cannot be done in a different order), etc. In this sense, the objective is often to find a “good enough” solution that respects all constraints for a particular work activity, rather than finding an optimum with respect to a particular criterion.
- Another observation is that the solutions put in place for a D&D project in one country cannot necessarily be transposed to D&D activities in another country. Each country may have distinct preferences in terms of overall dismantling strategy, and in terms of waste types, size, conditioning process to meet acceptance criteria, or to meet a free release threshold. Also, the selected waste repositories in each country can greatly differ and influence the D&D processes.

- Two tools connected to the platform using "theoretically" the same data can give different results. This is further discussed below, as it relates essentially to potentially different interpretation of the data, or different calculations methodologies (with their own set of assumptions).
- It is to be noted that as such, the PLEIADES platform does not make the process of collecting and validating the data of tangible assets easier (we are referring to the inventory of assets to be dismantled; their geometry, physical properties (mass, material, etc.), radiological characterization). Reaching a high level of completeness and validation is essential to be able to realize correct estimates for D&D activities.

### 2.1.5. Concluding comment

All the interviews show that users will continue to work according to their established processes and historical tools in parallel with the adoption of the PLEIADES platform. This is for the various reasons explained above. It must be considered that there will be a period of adaptation and break-in to use. There is in fact no technological barrier to adopt the "BIM approach". The main difficulty is probably to convince users and have them adopt a new mindset with respect to working processes and data management.

One way to facilitate the adoption of the platform would be to initially focus its use on a few types of studies for D&D (e.g., dose calculation).

It would also be easier to target certain user profiles if we had a better vision of how to market the use of the platform. This is also very important to select on which development the efforts must be put in priority.

Another remark is that providing examples and tutorials on the way to use PLEIADES platform would also greatly help acquiring rapidly the basic understanding of how it works.

Also, sales brochure or advertising material would help the dissemination process.

## 2.2. Data management and class definitions

In this section, the viewpoint of the evaluation is the actual implementation of the D&D ontology in the PLEIADES platform, and the evaluation of data management processes through the platform, to support the D&D work activities.

### 2.2.1. Introductory comment

The PLEIADES platform implements a "Common Data Environment" (CDE). By definition, a CDE enables all stakeholders on a project or asset to work on and share information in a consistent and coordinated way. It is also there to ensure the quality, reliability and security of the information throughout the project lifecycle.

The information that must be stored and exchanged for nuclear D&D work activities has been formalized through the D&D ontology (D2.4). The objective for this ontology is to standardize the communication between stakeholders/applications involved in the D&D.

The MongoDB database system has been selected to implement the data structure of the D&D ontology. The concepts in the ontology were assigned to “data classes” of the database. A data class defines the collection of information (or “properties”) that can be associated to a concept.

MongoDB system is flexible by supporting dynamic data schemas and the use of various data types and allowing complex queries. It is also reliable and scalable to the needs of a growing database. These features made it a very good choice for developing the PLEIADES platform, allowing to integrate rapidly the new needs identified along the way of the development and testing of the user stories.

Next to MongoDB, an object storage system was implemented with the MinIO framework, compatible with Amazon S3 cloud storage solution. This system allows to store any kind of file format in a centralized repository. The term “buckets” is used in this context instead of the more common “directory” term. Also, the terms “object”, “file” or “document” are interchangeable here. In the MongoDB database, we refer to “documents” stored in the MinIO. These “documents” can be any file type (text, image, 3D models, spreadsheet...).

### 2.2.2. Strengths

The main strengths of the proposal data management implementation identified by the partners are listed here:

- A recurrent feedback received from the users is that the D&D ontology set-up within PLEIADES and the implementation in the data classes of the platform is covering most of the information that is needed for D&D work activities management. This is very important and positive of course and it reaffirms the validity of the approach.
- The specificity of a nuclear D&D project is of course the management of radiological material. The platform can be used to store the data for spectrum and sources, along with their activity and location. These data can already allow covering a large part of the nuclear specific calculations.
- Another important feature was the adoption of an API following a standard framework. This was greatly appreciated to ease the connection of the applications to the platform.

### 2.2.3. Suggestions, additional needs

The partners identified the following suggestions and needs:

- The definitions of class properties in the data structure could be more comprehensive. In general, it is clear what data class should be used for which purpose. But the explanation leaves some room for interpretation. It was observed in practice that different users could have different strategies for storing the same type of information. Proposing more examples of usages of the data classes would certainly help the learning process for new users and help adopt standardized methods of working with the platform.
- There should be a way to precisely define the scope of each data, i.e., telling for which use it is validated (and *a fortiori*, for which use it is *not* validated). Some data may be very coarse, but still perfectly valid to perform preliminary estimates, while more accurate / validated data may be required for detailed preparatory work. Communicating over the scope of a data can be achieved at least partially through the use of the data class “description” property. But a

more systematic and structured approach is required to be able to scale the functionality on a real D&D project.

- When preparing work activities and comparing different hypotheses, different estimates can be produced (costs, quantities, schedule, etc.). The estimates remain virtual until the work is actually performed. A pragmatic approach to keep track of those estimates and the associated hypotheses has been set up with so called “scenarios” classes. A more comprehensive standardization of this process would be needed, to ensure that the estimates can be understood the same way from all potential client applications.
- Also, no precise communication mechanisms between the applications were implemented. If an application uploads, processes, updates some data that feeds the processing of another application, there should be some kind of messaging system to alert the availability of the new (or updated) data. This is particularly important for repetitive tasks that would certainly be automated. In the WP3 testing, the exchange of messages between applications was done manually through human communication, as the simulation for these fictive cases didn't require that many exchanges.
- Another need mentioned is to be able to get through the platform the list of data that must be provided in order to use a particular application (note that this information should also be available through the interface of the interconnected application).
- It was observed that new needs for data storage appear along the way, that are not part of the ontology. It should be possible to add new data classes or update some classes. Of course, this should be realized under a formal review process, ensuring that the updates stay in line with a common ontology for all applications (the risk being that each application create its own “user defined” ontology for practical reasons, losing the possibility to share information between applications).
- A help module for step-by-step data collection would be appreciated (and this need refers also to the creation of good examples and training material mentioned earlier).
- Access policy was until now not put in place (anyone with an account for the platform could read and modify any data). Setting rules for who can read / write which data is an absolute necessity for a real D&D project. For the purpose of testing the platform, the possibility to easily delete a whole database (intentionally or not) was left. This is of course the last thing that we want to allow in a real project.
- True versioning of the data is also a functionality required on real projects. This should provide a way to know what data has changed and if it can have an impact on analyses performed previously.
- Related to the access policy, better security of the database is required, given the sensitivity of the information that can be stored in the database. The location of a server on premises is certainly an absolute requirement for many clients. And the possibility to access the data from everywhere would certainly be conditioned to the use of complementary security technologies.

#### 2.2.4. Other observations

The following “neutral observations” were also made regarding the data management through the PLEIADES platform:

- There is some large overlap between the class definitions of the PLEIADES platform and the structured data that can be linked in a BIM model. In particular, if there are already 3D models expressed in IFC formats, with associated data, copying these data in the PLEIADES database doesn't seem to be the right approach. Some synchronization service would be necessary to ensure that the (external) BIM model refers to the same data as the PLEIADES platform. This risk could have been handled differently by extending the IFC format with D&D specific data classes (in particular, a way to add properties to tangible assets for storing radiological information). Many concepts are already present in the IFC standard. Implementing the D&D ontology as an extension of the IFC would have also help the adoption of the platform as many software applications are readily available to provide advanced reviewing functionalities for data stored through the IFC standard.
- The MinIO can be used to store any file format. In particular, proprietary formats that can be read only through specific applications. While this solution is perfectly valid and pragmatic, it can sometime go against the spirit of interoperability between the applications. In that sense, the use of standard formats that can be read by most applications should be encouraged.
- If major software vendors in the industry were to adopt PLEIADES, it would probably provide a big boost in the development and a path to make it a standard. The business development in this context could be easier (to be confirmed).
- Flexibility of data structure has some advantages during development phase, when the needs still appear during the experimentation. But it also represents a caveat for reaching more rapidly standardized working processes. We could imagine keeping some part of the database relatively flexible to allow integration of new data needs, and on the other hand, be stricter on other parts of the database, when the proposed structure has already proved effective for the needs.

## 2.3. Platform User Experience

In this section, the viewpoint of the evaluation is on the user experience for the functionalities of the PLEIADES platform put in place at the level of the server. The user may also have a different experience when connecting to the platform through the interface of one of the connected applications. We do not consider this aspect as it highly depends on the application and on the way the connector was implemented.

### 2.3.1. Introductory comment

Different users will have different needs; each one will assess the experience of working with the platform from his own perspective. We will consider here a “generic” user, which has to review or fill some information in the platform. We first look at the experience through the browser interfaces to access the elements of the database, both the MongoDB database (which implements the ontology classes) and the MinIO object storage. The interface through the browser could be considered as one of the connected applications. But the idea is to provide this interface to all users, and as such to make it part of the experience of working with the platform.

Concerning the interfaces through the connected applications, the user experience should in principle not differ whether the application is connected to the PLEIADES platform or to any other database. At least, this is true if the interface with the platform could be conducted properly (i.e., there is no loss of information in the data exchanges from-and-to the application / platform and there is no programming error in the connector implementation).

### 2.3.2. Strengths

The following strengths were mentioned by the partners to describe the user experience through the browser functionalities:

- The browser interface for the MongoDB database is functional, simple to use, there are not too many buttons to get lost.
- The content of each entry in the database can be easily accessed / viewed. This makes it easy when developing connectors to check that the connection is working properly.
- The definition of the data structure for each class is readily available in the browser, which helps the learning.
- There are easy to use search functionality that allows to quickly get the data containing a particular (sub-)string.
- The storage of any file type through the MinIO interface is also simple and easy to use.

### 2.3.3. Suggestions, additional needs

The partners identified the following suggestions and needs:

- At this stage, the user interface is limited to basic functionalities. A question is whether additional functionalities should be obtained through the use of a dedicated “user interface tool” or should be part of the standard package offered to any user of the platform (and doing so, it would be seen as part of the platform rather than a separate tool). We refer here in priority to functionalities helping for “reviewing” the data (compared to applications that are meant to feed and process the data).

The main functionalities that come to mind are those offered in the BIM viewer and manager applications:

- Viewing of the 3D models, with direct link to data associated to each component;
  - Structuring of the data according to user defined templates (spatial, functional, task related, etc.);
  - More advanced filtering functionalities to rapidly get useful extracts;
  - Possibility to tabulate results from queries / filters, or to generate spreadsheets;
  - Possibility to view easily linked data, bidirectionally (i.e., get all the data that have referenced a particular information).
- In the course of the WP3, the users accessed those functionalities through the connected applications, or by downloading the models and data, making then use of separate software (BIM viewer, office applications, etc.). This way of doing is perfectly operational, but it is certainly not providing the best user experience.

- It would improve the experience if a link to a record in the MongoDB database was automatically generated when a file is uploaded in the MinIO. Currently, a “document” record has to be created manually, and the address of the file in the MinIO has to be indicated. Making the process more automatic would prevent forgetting to create a link (and that the file has then no existence for the database). Also, this link shouldn’t break if the file is moved from one place to another within the file structure of the MinIO repository.
- There is no predefined process or guidelines for structuring the documents in the MinIO repository. This is left to the users’ responsibility. As long as the number of files remains small, it isn’t a problem, but for larger projects where many stakeholders may have to share and access documents, it is essential that a well thought structure be defined.

### 2.3.4. Other observations

The following “neutral observations” were also made regarding the user experience with the PLEIADES platform:

- There is currently the possibility for copying databases and create sub-database. This can be viewed as a favourable feature within the process of generating different modelling scenarios and testing various hypotheses. However, it is also viewed as a potential risk as it breaks the principle of “single source of truth”; according to this principle, a data should be defined at a single place to ensure that every user relies on the same information.
- It would help having a menu to get a "platform user manual". The user could directly get an explanation on particular data class properties, and how it should be used for specific work processes. This can be complementary to setting up the training materials (already mentioned above).
- The same is true for having a user manual on the MinIO interface (in particular, regarding the particular vocabulary of the platform that new users may not be familiar with).
- Although the browser interfaces are quite simple, in their current form, a new user would need guidance from more experienced users to know how to work with the database. This could again be tackled through the training material.

## 2.4. Developer’s feedback

In this section, the viewpoint of the evaluation is from the perspective of the developers that worked on implementing connectors to the platform.

### 2.4.1. Introductory comment

One of the conclusions regarding the development of a business model around the PLEIADES platform is that the connection of new applications should be encouraged, to enlarge the community of users and probably increase the means to further develop the product. For this objective, the possibility of making Open Source the definition of the platform API (Application Programming Interface) was discussed and agreed.

With the feedback of the developers that have already worked on connectors, it is possible to better assess what the barrier could be for new applications.

## 2.4.2. Strengths

The developers mentioned the following strengths to describe the PLEIADES platform:

- The availability of examples to showcase the use of the API was very appreciated as it greatly simplified the development of new connectors between the applications and the platform.
- Making the class definitions readily available through the browser is also important from the perspective of the developers.

## 2.4.3. Suggestions, additional needs

The following suggestions and needs were identified:

- There should be a way to ensure programmatically that all connections are made with the data classes, to be sure that we do not forget some data fields in the transfer processes (having data that never reach their due destination).
- The API of the PLEIADES platform is currently not strict regarding data types (e.g., it is possible to interchange numbers, words, etc.). It is in fact very flexible for the moment as about any data can be transferred as long as it fits the JSON format. This presents a risk for introducing errors and it goes against the standardization philosophy. It can also be problematic for interfacing the platform through some programming languages. Working with “typed” constraints on the data exchanges is considered a need for the future in the context of D&D projects as it is a simple safeguard ensuring that the right data type is inserted in the right field (e.g., preventing the encoding of a text in a field where a list of numbers is requested).
- It was also commented by the developer that the security of data should be improved. This is also related to the implementation of an access right policy (discussed earlier).

## 2.4.4. Other observations

The following “neutral observation” was also made from the developer perspective:

- Packing and unpacking the data into a JSON format for transfers through the API (via the HTTP protocol) is a relatively standard process but certainly not straightforward. It requires to have a good understanding of both the data structure within the PLEIADES data classes and within the connected applications. It is easy to miss a detail or forget some links when doing such conversion process (e.g., a data that would be expressed in a particular unit on PLEIADES and in another unit in the connected application).

## 3. Optimization of the global approach

This chapter relates to task 4.3 of the project: “Optimization of the global approach”.

Based on the evaluation of the results of the overall approach developed and demonstrated in work packages 1 to 3, we attempt to propose potential improvements to the approach and methods of the project (see Section 3.1).

The specific elements to be optimised are the accuracy and management of the required input files, the ALARA planning, and the use of sensitivity analysis to evaluate alternative scenarios. But potential improvements are also proposed for other aspects of the global approach (see Section 3.2).

### 3.1. Potential optimization to the approach developed and demonstrated in WP 1 to 3

This chapter groups the proposals into 3 sub-chapters, one for each of the first 3 work packages.

#### 3.1.1. Optimising the approach developed in WP1

The potential improvements listed below are related to topics covered in work package 1 of the project “Requirement analysis, specification and test design”.

##### 3.1.1.1. Platform requirements

The requirements defined as part of WP1 were many and varied (see D1.1). These represented the different specialities of all project partners. In this sense, it was normal to have varied requirements, since the technical positioning of the different partners could be quite different, and therefore the needs in terms of functionality were also different.

Nevertheless, perhaps a different approach at this level, by choosing to specify a platform that was more specialised in certain areas, rather than one that covered all the needs, would ultimately have resulted in more accomplished functions and a simpler, more functional interface.

For example: focus exclusively on 3D, BIM and dismantling operations, in order to estimate the duration and cost of dismantling operations, as well as the waste generated. And thus, leave aside the possibility of carrying out radiation protection and safety/security studies.

To do this, we should have initially left out certain requirements, in view of the simplicity of all the other stages of the project, and more generally to simplify the creation of a functional demonstrator, while retaining the option of adding certain functions later.

##### 3.1.1.2. User stories and use cases definition

The 6 user stories were chosen to present a diversity of work activities (Cf. D1.2). For example, and schematically:

- US#1 involved radiological measurements in a research reactor,

- US#2 planned to cut and remove a large heater in an annex of a nuclear power plant,
- US#3 concerned remediation operations in a nuclear maintenance building.

Nevertheless, at the beginning of WP3, retrieving real data or generating hypothetical data from these 3 real use cases was particularly time-consuming and technically not very relevant. A potentially better approach would have been to pass on the responsibility of “use case owner” to some partners. With the freedom of the owner to generate fake projects with fake data, we would have had the perfect data for user stories faster, without data collection issues at the testing stage.

However, with this approach, another work package, potentially parallel to WP4, would have been necessary to test the platform on at least 1 real case, with a real “miniature” project and real data, mainly to test the methodology for collecting project data and create associated database in the PLEIADES platform.

### 3.1.1.3. PLEIADES Ontology

Defining the ontology at the beginning of the project was a unifying exercise for all partners (Cf. D1.4). Each partner had the opportunity to highlight the main data and processes that they used during their studies, in order to integrate them into the project ontology. As the different partners have different specialities, these discussions were very interesting and useful for the rest of the project.

Nevertheless, something that could have helped with the ontology, when defining its first version, is to assign also a partner responsible for updating the ontology over the course of the project. In fact, as the project progressed, certain parts of the ontology became outdated, because certain terms or methods defined as part of WP1 were no longer strictly up to date when the platform was being developed or tested.

## 3.1.2. Optimising the approach developed in WP2

The potential improvements listed below are related to topics covered in work package 2 of the project “PLEIADES platform development”.

### 3.1.2.1. Platform architecture

It is within the framework of task T2.1 (see D2.1), that we chose to validate the use of a specific server for files (MinIO server), and another server dedicated to databases (JSON format).

The ideal would have been to have a single server interface which could manage data/metadata, and large files. But this would potentially have led to new issues during the development of the platform, and it is not certain that the user experience would have been better.

### 3.1.2.2. API structure

During task T2.2 (see D2.2), it was decided to allow some flexibility in the declaration of properties for many API classes. This was an advantage later for task 3.1, when declaring data to populate the

databases for the 3 uses cases. However, for partner developers who had developed a connector for their tools, this flexibility was more suffered than appreciated. Indeed, for data with formats that are not strictly defined, it is difficult to foresee their integration into the tool databases.

### 3.1.2.3. Platform functional tests

It is within the framework of task T2.4 that all partners with at least one tool connected to the platform carried out functional tests to validate the general functioning of the PLEIADES platform.

Optimization would have consisted, for the different tools and their connectors, of planning a series of final and specific tests. In fact, the functional tests were largely the same for all partners; for example: test reading, writing and deletion in the database, create a bucket in the MinIO server, etc. Thus, we could have detected possible limitations for certain tools to carry out certain parts of the user stories. Which was ultimately the subject of the start of WP3 second part relating to user story testing.

### 3.1.3. Optimising the approach developed in WP3

The potential improvements listed below are related to topics covered in work package 3 of the project “Implementation of PLEIADES platform on real use cases”.

#### 3.1.3.1. Development of 3D models

As part of task 3.2 relating to 3D models, an optimization of the approach would have consisted of predefining different situations concerning the 3D models of the use cases. This means varying the use cases in terms of 3D data, as we have done by defining various user stories.

For example, we could have envisaged the following different starting states, and seen what level of work was necessary to obtain a “usable” 3D model:

- 3D model non-existent → Need to create a first version of a 3D model,
- 3D model to be verified → Using a point cloud to check it,
- Only point cloud available → Using the point cloud to build the 3D model,
- SolidWorks model only → convert the model to IFC.

#### 3.1.3.2. Development of BIM model

From the start of the project, in order to orientate it more towards the BIM technology currently being developed, we should have defined the ontology with the possibilities offered by the IFC format. As a result, the IFC format would have become the platform’s main language, and not just that of 3D data.

This would have had the advantage that all software that is already IFC-compatible would be more easily connectable to the platform, and we would have made greater use of the possibilities offered by the fact that 3D objects carry a variety of data.

However, we would certainly have had greater difficulties during development, and also when connecting with the tools of certain partners who are not particularly compatible with IFC.

## 3.2. Potential optimization to specific attributes of the platform

### 3.2.1. Optimisation of the accuracy and management of the required input files

For a platform like PLEIADES, the input data is the core of the initial requirement. The input data available directly defines the studies that can be carried out and the results that can be obtained. For example, it is impossible to estimate dosimetry for operators without a radiological inventory of the work sites.

In order to increase the platform's chances of being used, one task could have been to develop a kind of form for project managers, to assist them in gathering input data.

This form must of course be based on the structure of the PLEIADES API, but it must also take into account the needs of the project manager. For example, the first part of the form could be devoted to defining the main expected results. Depending on the answers, the project manager might need to provide some data exhaustively and with great precision, while other data might not be necessary, or imprecise estimates might suffice.

Moreover, in PLEIADES, several types of data can "do the job". So, for each type of data, this form would present the project manager with the different classes of data he can provide. Reusing the example of dosimetry: the duration of planned operations is necessary. However, it is not mandatory to know each duration for all operations. In fact, it is possible to use a ratio and other data to calculate the duration of planned operations. Let's take the example of a radiological inspection operation on a wall: the duration can be obtained by knowing the surface area of the wall and the area operated per unit time in  $\text{m}^2/\text{h}$  for example. The project manager is not obliged to provide the duration of this operation, as it can be calculated from other data he or she has declared.

### 3.2.2. Optimisation of ALARA planning

Regarding ALARA studies, one minor optimization that could be made to the platform concerns the position of the main operator performing the operation (i.e., the one holding the tool).

Radiological sources can be precisely positioned, and other team members' exposures can be estimated using Worker Exposure Ratios. However, the position of the main operator is difficult to define. This is one of the reasons for the discrepancy in dosimetry estimates for the US #1 scenarios.

The solution that could be implemented in the platform could be to add a property for text format to the "Task" class, like "Task\_MainOperatorLocation".

### 3.2.3. Optimising the use of sensitivity analysis to assess alternative scenarios

Although defined and developed late in the platform (during WP3), the PLEIADES API classes for sensitivity analysis meet the main needs of this exercise. Indeed, the "Scenarios" class and the

"Scenarios.Runs" subclass contain all the essential properties needed to define and perform these analyses.

An optimization could be to automate the realization of the different runs. However, this optimization would seem to be more appropriate for the tools connected to PLEIADES than for the platform's API.

## 4. Conclusion

The evaluation work carried out in the framework of WP4 has resulted in much feedback from different perspectives on the solution proposed in PLEIADES. Also, many ideas for further development of the platform and further optimization of the work methods were formulated.

The main messages that emerge are summarized here:

- The approach implemented through the platform and connected tools already covers a large number of studies and management activities of a nuclear D&D project.
- The partners believe that the main resistance to adopting the platform is more psychological than technical. It's not easy to change your work habits, and integrating methods into a data-centric process requires a change in mindset.
- Ways to make the use of the platform more easily accessible are:
  - o Set up examples and learning materials;
  - o Have user manuals directly accessible in the interfaces, and be able to support users;
  - o Enable the adoption of the system in a phased manner, by providing tools to transfer data, or by focusing the use of the platform first on certain studies only.
- The majority of partners also believe that the solution could be even more attractive with the interconnection of additional applications. In the future, we should seek to encourage this possibility of increasing the constellation of applications that can be connected to the platform. To move in this direction, the open-source distribution of the API and class definitions has been identified as a necessary step.
- From an implementation point of view, users consider that the proposed solution and the ontology put in place meet the needs identified at the outset. The use cases have been demonstrated in the framework of WP3. It will of course be necessary to set up a process to complete/adapt the ontology and data classes in the future.
- Many aspects can be further developed, and some features not yet implemented will be indispensable in the nuclear context (such as a stricter/secure data access policy). The elements to be developed as a priority will depend on which "business case" is being targeted at first.
- From the point of view of the user interface and the API set up to develop the connectors, here too the partners rate the solution as suitable and fulfilling the main needs well.

## 5. References

- [1] PLEIADES, D1.1 - Requirements for the design of the PLEIADES concept (public)
- [2] PLEIADES, D1.2 - Specifications for the PLEIADES system prototype and validation tests
- [3] PLEIADES, D1.4 - Ontology describing a nuclear decommissioning project
- [4] PLEIADES, D2.1 - PLEIADES platform software architecture, (confidential)
- [5] PLEIADES, D2.2 - PLEIADES software interfaces, (confidential)
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