Lessons learned in the FARO dismantling process I

LESSONS LEARNED REPORT

KP-JRC-001

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Foreword

In 2021, the European Commission (EC) adopted a new proposal for a Council Regulation[1] establishing a dedicated financial programme for decommissioning nuclear facilities and managing radioactive waste. This instrument covers the co-funding of the decommissioning programmes of Bulgaria, Slovakia, and the decommissioning of the Joint Research Centre (JRC). A separate Council Regulation[2] was adopted for the decommissioning programme of Lithuania.

The EC JRC is mandated to foster the spread of decommissioning knowledge across all the European Union Member States and facilitate knowledge sharing arising from implementing the abovementioned decommissioning programmes, funded by the Nuclear Decommissioning Assistance Programme (NDAP).

The decommissioning operators from the NDAP (NDAP Operators) implemented and tested a knowledge management methodology in 2021 through Project ENER/D2/2020-273. Using this methodology, the NDAP Operators can develop Knowledge Products that are currently available to share with other European stakeholders. In addition, this methodology is under implementation in the JRC Nuclear Decommissioning and Waste Management Directorate (NDWMD), which becomes a knowledge generator extracting the knowledge from the ongoing decommissioning activities at the different sites (Geel, Ispra, Karlsruhe, and Petten).

The JRC NDWMD aims to become a Centre of Excellence in nuclear decommissioning knowledge management and develop a decommissioning knowledge platform which allows exchanging information and building on the best practices in the EU inside the multi-annual financial framework (2021 – 2027) strategy. The operational phase of the project is expected to start in 2024 to develop ties and exchanges among EU stakeholders and document explicit knowledge and make it available through multi-lateral knowledge transfers on decommissioning and waste management governance issues, managerial best practices, technological challenges, and decommissioning processes at both operational and organisational level, to develop potential EU synergies.

This is a Knowledge Product prepared by the Nuclear Decommissioning and Waste Management Directorate (NDWMD) – Directorate J of the Joint Research Centre.

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[1] Council Regulation (Euratom) 2021/100 of 25 January 2021 establishing a dedicated financial programme for the decommissioning of nuclear facilities and the management of radioactive waste, and repealing Regulation (Euratom) No 1368/2013

[2] Council Regulation (EU) 2021/101 of 25 January 2021 establishing the nuclear decommissioning assistance programme of the Ignalina nuclear power plant in Lithuania and repealing Regulation (EU) No 1369/2013

PRODUCT DESCRIPTION

The NE.40.2220.SR.002. Lessons Learned report was prepared by a team of experts from JRC Decommissioning & Rad Waste Organization at JRC-Ispra in Italy. The guidance and recommendations of this product are collected from the experience gained during the execution of the FARO dismantling process sponsored by the European Commission via the Nuclear Decommissioning Assistance Program (NDAP) between the years 2013-2015.

The lessons learned in this report aim to **assist personnel in nuclear decommissioning preliminary activities**. Firstly, it mentions the main elements of the process (e.g., destructive analysis, classification of materials, equipment used…) to provide an overview of how the methodology at JRC-Ispra. Later, the document shows some unsatisfactory results related to process management and technical procedures. These results are finally used to suggest a different approach to clearance processes to avoid those inconveniences.

This product was developed as part of an effort to disseminate and share with all EU State Members the knowledge acquired during the decommissioning and radioactive waste management activities performed by the JRC Directorate J.

ABSTRACT

FARO dismantling project I-04-05-01 is one of the first complete decommissioning projects implemented in JRC-Ispra. FARO was the Fuel Assembly and Release Oven building inside Ispra's facilities. Considering the lack of experience in this kind of activity, JRC has decided to split the activities into two main steps and to analyse the progress at the end of the first step. This is paramount for continuing the FARO deconstruction and long-term activities such as INE deconstruction.

OBJECTIVE

This knowledge product aims to provide a possible approach to future preliminary activities related to clearance works in decommissioning projects based on experience obtained during the FARO characterisation, design and beginning of deconstruction phases.

APPROACH

The project team incorporated experiences and lessons learned from the dismantling of JRC's Ispra facility until the end of June 2013 in the Archive of Directorate J..This lessons-learned document was developed by IDOM Engineering, Consulting and Architecture from the documentation available in the Archive by July 2023. Results from the site's past contamination reports (Memorandum W01/114/92 *Denuncia di incidente Impianto Faro*, July 1992) were incorporated in the original document and software like MIRADIS was also useful for adding information on contamination risk/expected level of contamination.

RESULTS, FINDINGS, AND INSIGHTS

This document guides the establishment of lessons learned during the preliminary activities for clearance procedures in the FARO dismantling project. The document presents the results obtained by the end of June 2013. The study covers the feasibility of a **new approach to future dismantling projects**. Lessons learned in this document evaluate new ways to **optimise costs and time in procedures to ensure safety in future dismantling projects.** For instance, this report will comment on the **reclassification and measurement of type D material** in order to avoid incoherences that might lead to **safety risks and unnecessary spending**. On another note, **many bottlenecks** that can appear during a clearance process **are identified**, hence a **modification of the logic of works** is suggested as the main solution to this problem.

TARGET USERS

The product targets a broad range of potential beneficiaries using this guidance. Technical profiles from the nuclear industry will not need long experience and knowledge in this sector to profit from the advice given in this document since it is project-oriented rather than technology-specific. Knowledge in this document can add immediate value to important agents in the field, such as operators or other EU stakeholders.

APPLICATION, VALUE, AND USE

This report may be used by other organisations due to the impact it shows the application of its lessons learned could have on other similar projects. This report may be used in other clearance processes (activities of removing materials from a certain site) due to the impact it shows the application of its lessons learned could have on similar projects. **These procedures could affect key aspects like safety and environmental protection (e.g., preventing cross-contamination) or managerial performance (e.g., time-saving measures).**

It will provide great service to the user of information since it contains experiences that can help other projects improve their existing processes, practices, or use of technologies in decommissioning activities. Lessons learned are related to the specific procedures in the FARO dismantling process and were subject to Italian regulation requirements; hence team projects would need to customise these lessons depending on their context. Despite that, recommendations made in this report have a general application, making their integration into other organisations easier than usual.

The report suggests a new possible approach that could lead to **an increase in productivity of 36%** and **a reduction of 11 weeks in the project's duration.**

KEYWORDS

FARO, DISMANTLING, MATERIAL CLEARANCE, RADIOACTIVE WASTE MANAGEMENT.

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LIST OF ACRONYMS AND DEFINITIONS

ACRONYMS

CC:	Clearance Container
CL:	Clearance Level
DA:	Destructive Analysis
FARO:	Fuel Assemblies melting and Release Oven
HG:	Homogenous Group
ISOCS:	In-Situ Object Counting System
ISPRA:	Istituto Superiore per la Protezione e la Ricerca Ambientale (Institute for protection and research of environment)
JRC:	Joint Research Centre of European Commission
LMR:	Site Laboratory
MCS:	Material Clearance Station
MDA:	Minimum Detectable Activity
NDA:	Non-Destructive Analysis
PPE:	Personal Protective Equipment
RP:	Radioprotection
SGRR:	Stazione di Gestione di Rifiuti Radioattivi
UMA:	Unit of potentially clearable material (Unità Materiale Allontanabile)
UNI:	Ente Italiano di Normazione (Italian Normalization Council)
WAC:	Waste Acceptance Criteria

DEFINITIONS

Clearance Container: Prismatic container of approximately 0.7 m^3 volume to which detectors of MCS are calibrated.

Scarrabile: Roll-off container approved for transport of conventional waste.

Homogenous Group: Set of materials with similar material typology, class of radioactivity, isotopic

composition and activity concentration (mass and surface).

Unit of Potentially Clearable Material: homogenous portion of the material on which the measurements are averaged to verify compliance with clearance levels.

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1. GENERAL BACKGROUND INFORMATION

This is a brief description of the clearance process in the FARO dismantling project to facilitate understanding of the issues treated along the document.

1.1. General Introduction to Clearance Process Requirements

This report includes the first activities of the FARO dismantling project implemented in JRC-Ispra, such as the classification of materials, destructive and non-destructive analyses, and clearance level measurements.

1.1.1. Legislation

The process of clearance is governed by Italian law [1], Italian norm [2], technical prescriptions of SGRR licence [3] (defining also the table of clearance levels), and JRC procedures ([4] and others referred to therein).

1.1.2. Types of Materials by Class of Radioactivity

There are 4 types of materials by class of radioactivity to be distinguished:

- Activated and contaminated (A)
- Contaminated (B)
- Activated (C)
- Presumably neither contaminated nor activated (D)

Depending on the material it is being worked with certain guidelines arere recommended to follow:

A, B, C	The number of UMAs to be subject to non-destructive analysis measurements is calculated from the results of the destructive analyses. **The more homogeneous the group, the less non-destructive analysis** measurements are statistically sufficient for clearance.
	The **minimum number of non-destructive analyses to be done is on 14 UMAs** in case of “very good” homogeneity
	When the homogeneous group is **less homogeneous**, the number of non-destructive analysis measurements rapidly increases and can achieve **measuring 100% of the UMAs**
D	**The ratio of non-destructive analysis measurements is fixed at 10% of the weight of the material** and must be controlled, and the regulator requested that the gamma total measurements have to be also confirmed.

Figure 1: Guidelines for material processing depending on their radioactivity class

1.1.3. Key Steps of the Process

FARO dismantling procedure contains the following steps. Their order must be maintained to avoid overlaps and delays during the project.

- **Initial characterisation of materials:** It enables to define homogenous groups (material of the same material composition, of the same radiological type, same nuclide vector and same level of contamination). The initial characterisation of material is based on analysis of MIRADIS data and supplementary investigation set up by the contractor.

- **Destructive analyses (DAs):** Each of the homogenous groups must be characterised through full range of destructive analyses. Destructive analyses are performed on samples of material taken before and/or during dismantling and sent to the Site Laboratory (which sends it further to Lot 6 Contractor). Several destructive analyses are equal to the number of UMAs in the homogenous group or 20, whichever is smaller. Therefore, the **definition of the size of the homogenous groups can have a great impact on the number of destructive analyses and their costs and their duration (delay).**

- **Definition of homogeneous groups**: The results of destructive analyses serve for preparing the decision if the material is clearable or is waste, and is used to determine the final nuclide vector, which will be then applied to recalculate the repartition in alpha, beta, and gamma, based on the total gamma provided either by a material clearance system or by ISOCS. It serves to define the level of homogeneity of the group – see Figure 2, and to define the number of non-destructive analyses to be provided – see Figure 3, because the process in Italy allows for less than 100% of material to be monitored when a statistically sufficient portion of measurements are compliant.

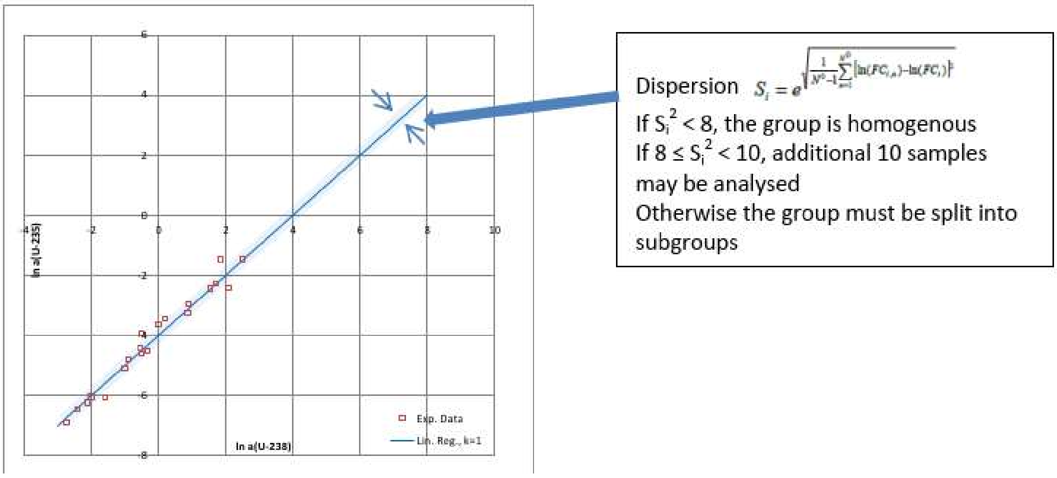

Figure 2: Test of coherence of the homogenous group (to be performed on each pair of radionuclides in the spectrum)

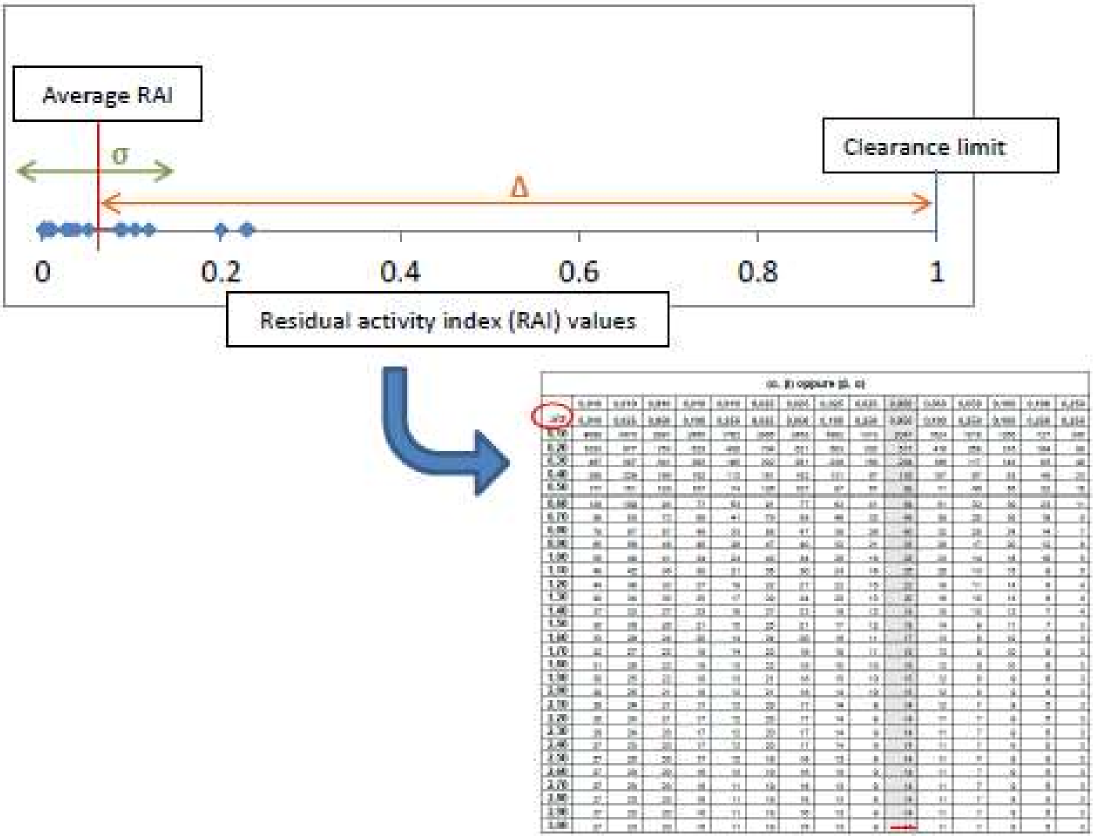

Figure 3: Determination of the prescribed number of UMAs for non-destructive analyses

- **Assignment of nuclide vector:** If the destructive analysis results confirm homogeneity, the final nuclide vector is assigned to the homogenous group. In case of non-homogeneity, 10 supplementary destructive analyses are requested to fix the issues. However, if the homogeneity test is not passed even with 30 samples, the homogenous group must be divided into homogenous subgroups.

- **Clearance levels measurements:** The step of the highest importance is at the end of this process - before the material is released from the Controlled Zone, it must be measured using bulk activity monitoring in a non-destructive analysis process. There are 2 options for non-destructive analysis measurements:

1	**Material Clearance Station System**: A dedicated total gamma counting system located in Area 40, designed for high sensitivities, and operated by SGRR
2	In-situ measurements with **ISOCS (In-Situ Object Counting System)**, operated by LMR. This method is portable and allows deployment close to the dismantling site

For all the steps mentioned in 1.1.3, it is also important to bear in mind that:

The limitation from the UNI norm on measurement units was 1000 kg or 1 m3 or 1 m^2. A further limitation was imposed by Ispra for metallic material (400 kg).
The sensitivity of this measurement must be very high at least an order of magnitude below the clearance levels.
Only gamma radionuclides were measured. The activities of other radionuclides were obtained by the application of scaling factors from the knowledge of the nuclide vector.

The fit of these steps with the dismantling is outlined in the figures below separately for Types **A, B or C** (Figure 4) and Type **D** (Figure 5). Some aspects of the measurement depending on the type of material are mentioned next:

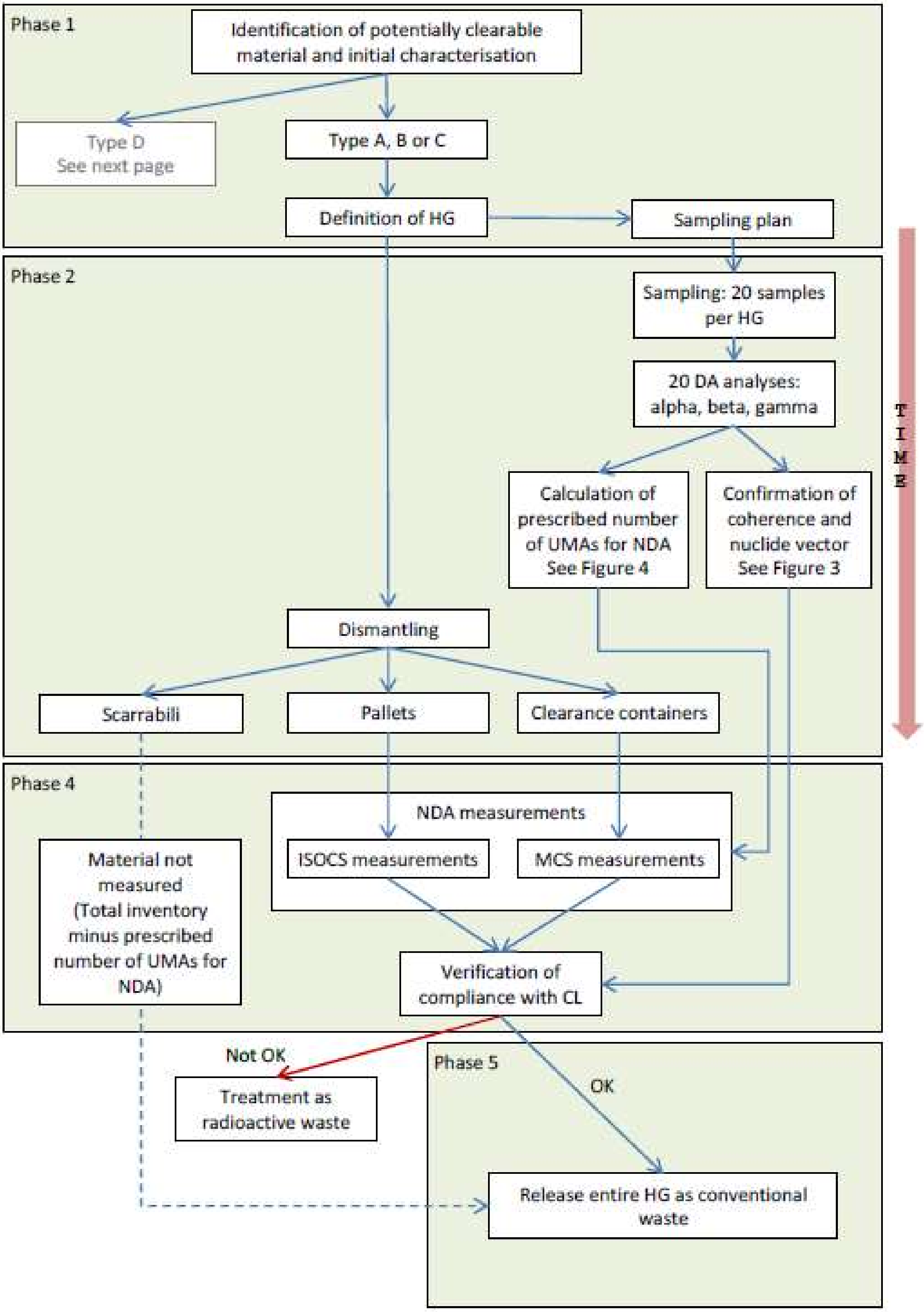

Figure 4: Graphical representation of the clearance process – Type A, B, and C material

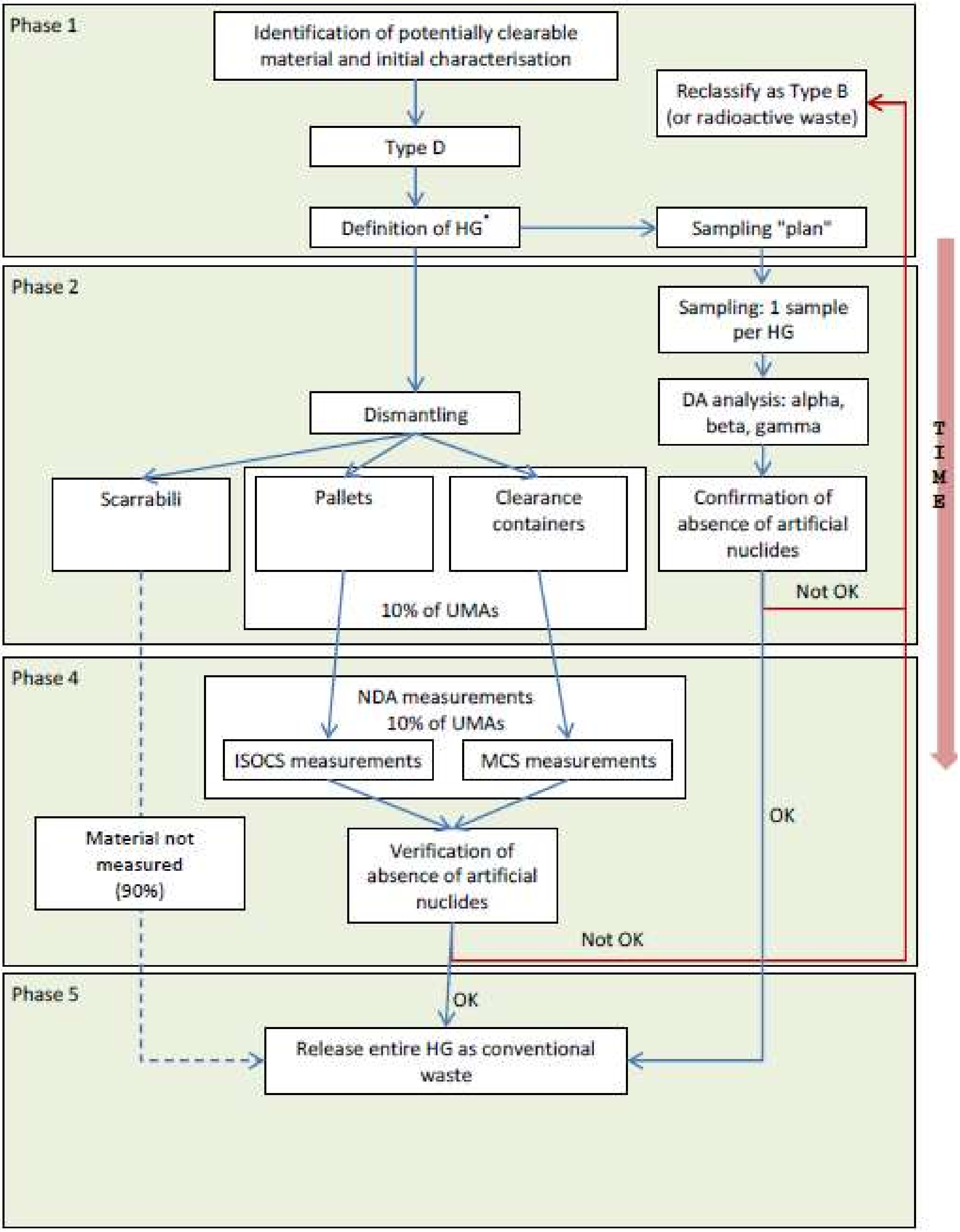

Figure 5: Graphical representation of the clearance process – Type D material

1.2. Radioactive Waste Management Requirements

Each dismantling project must produce a **Waste Management Plan** compliant with the requirements of the Decommissioning Plan / Detailed Design and those of the Waste Acceptance Criteria of SGRR. These waste management plans provide comprehensive information on the nature and quantity of waste generated by dismantling activities and identify the specific waste compliance documents from the WAC suite ([5] and the references therein) that the wastes will conform to. Furthermore, a Waste Characterisation Plan is required before the radioactive waste's characterisation, treatment, and conditioning.

The Waste Acceptance Criteria recognises the following waste streams and associated WAC documents:

Table 1: WAC documents associated with waste streams

WAC: PT1	Abrasive Decontamination of Radioactive Metallic Waste
WAC: T1	Melting of Radioactive Metallic Waste
WAC: T2	Incineration of Combustible Radioactive Waste
WAC: T3	Supercompaction of Solid Radioactive Waste
WAC: T4	Treatment of Radioactive Effluent
WAC: BS1	Buffer Storage of Orphan Radioactive Waste
WAC: BS2	Buffer Storage of Radioactive Sludge
WAC: BS3	Buffer Storage of Category 3 Radioactive Waste
WAC: C1	Conditioning of Category 2 Solid Radioactive Waste
WAC: C2	Conditioning of Category 2 Mobile Radioactive Waste

2. SCOPE

This report proposes a preliminary checking of the first results related to the clearance material management, radioactive waste management and work organisation on site by looking back to the methods and organisation of work, identifying lessons learned related to material classification, dismantling procedures and homogeneous groups definition (for possible improvements) for further recommendations about destructive analyses, equipment, and process management in future dismantling projects.

3. LESSONS LEARNED

This section shows the main hurdles similar works may encounter thanks to the experience gained during the FARO dismantling project. Possible solutions applicable to any clearance process are also included.

3.1. Special Clothing Limitations

Wearing special clothes, depending on the associated risks, is necessary. Tyvek overalls and full-face masks were prescribed for work inside the airlocks, even in case only potentially clearable material is manipulated (dressing /undressing 4 times per day: (**2 hours per day and worker**).

Legislation limits working with full-face masks, damaging productivity.

Although not embedded in law, there is a **widely recognized limitation for work in the full-face mask and suits as 2 x 2 hours per day**. *(Note: In France, dressing and undressing are included in this maximum time, so the effective working time in the full-face mask is in France 2 x 1.75 hours per day.)* **Therefore, the work performed in the full-face masks limited the productive working time to 2 x 2 hours per day**. There are several options **to overcome** this limitation:

TIP 1: Request the contractor to **organise the work in shifts** of two alternating teams performing other 2 x2 hours of work in a different worksite not requiring the masks.

TIP 2: Request the Radioprotection to **review the need for full-face masks** for handling potentially clearable material and consider the use of simple respirators once the material to be handled has been decontaminated (e.g., vacuumed) or covered with contamination fixation medium.

TIP 3: Consider a risk-based approach to the need for wearing the masks (masks to be put **on only for operations of opening** the circuits/components to be dismantled until the RP check confirms the material is potentially clearable).

TIP 4: Work on a continuous slot, which implies having at disposal the RP technician and the medical staff on duty

Working on continuous slot (TIP 4) is estimated to produce an 18% gain in productivity

3.2. DA Sampling Acceleration

Clearance containers only were created once the destructive analysis results were obtained and processed to fit the necessary number of non-destructive analyses. (See also Figure 6: Graphical representation of the possible improvement of the clearance process and cost-benefit analysis in **¡Error! No se encuentra el origen de la referencia.**. Therefore, **dismantling activities shall be rescheduled to allow for the completion of destructive analysis sampling and analysis as early as possible**.

The destructive analyses were performed by the off-site contractor (Envinet) and due to the stack up of the different actors (Contractor, RPS, LMR, transport, Envinet) there was a complete processing time of **minimum 3 months** between the sampling and the reception of the result of the analysis. Recently, it transpired that LMR was performing their own measurements before dispatching the samples to Envinet, which extended the waiting time even more.

It is reminded that by the end of June 2013, 6 t of potentially clearable material were in 28 clearance containers while the plan was to cut 33 t into 92.

The logic behind destructive analysis up to now (taking samples as the first dismantling action in each room) was justified by avoiding the duplication of some preparatory works such as raising a scaffold.

Accelerating the destructive analysis sampling will enable the processing of the results and calculating the number of required non-destructive analysis measurements before the dismantling activities are finished. Taking into account UMAs on pallets that will be measured by ISOCS, and the number of clearance containers already prepared, it will be possible to prepare the only exact number of additional clearance containers to be measured by retrieval of material from bigger containers / scarrabili (if any more are needed).

To achieve this goal, the **production of clearance containers by fragmentation into small pieces must be stopped and dismantling needs to continue in as big as possible pieces loaded directly into bigger containers** The following options should be looked at in the modified design:

TIP 1: To wrap-seal dismantling pieces into plastic foil, tag, check for the absence of external contamination and compliance with dose rate requirements, and transfer into containers

TIP 2: To dismantle **pieces loaded directly (without wrapping) into suitable buffer storage** containers sized to fit into hatches and can be brought into the controlled zone to the dismantling site.

TIP 3: Combination of the above

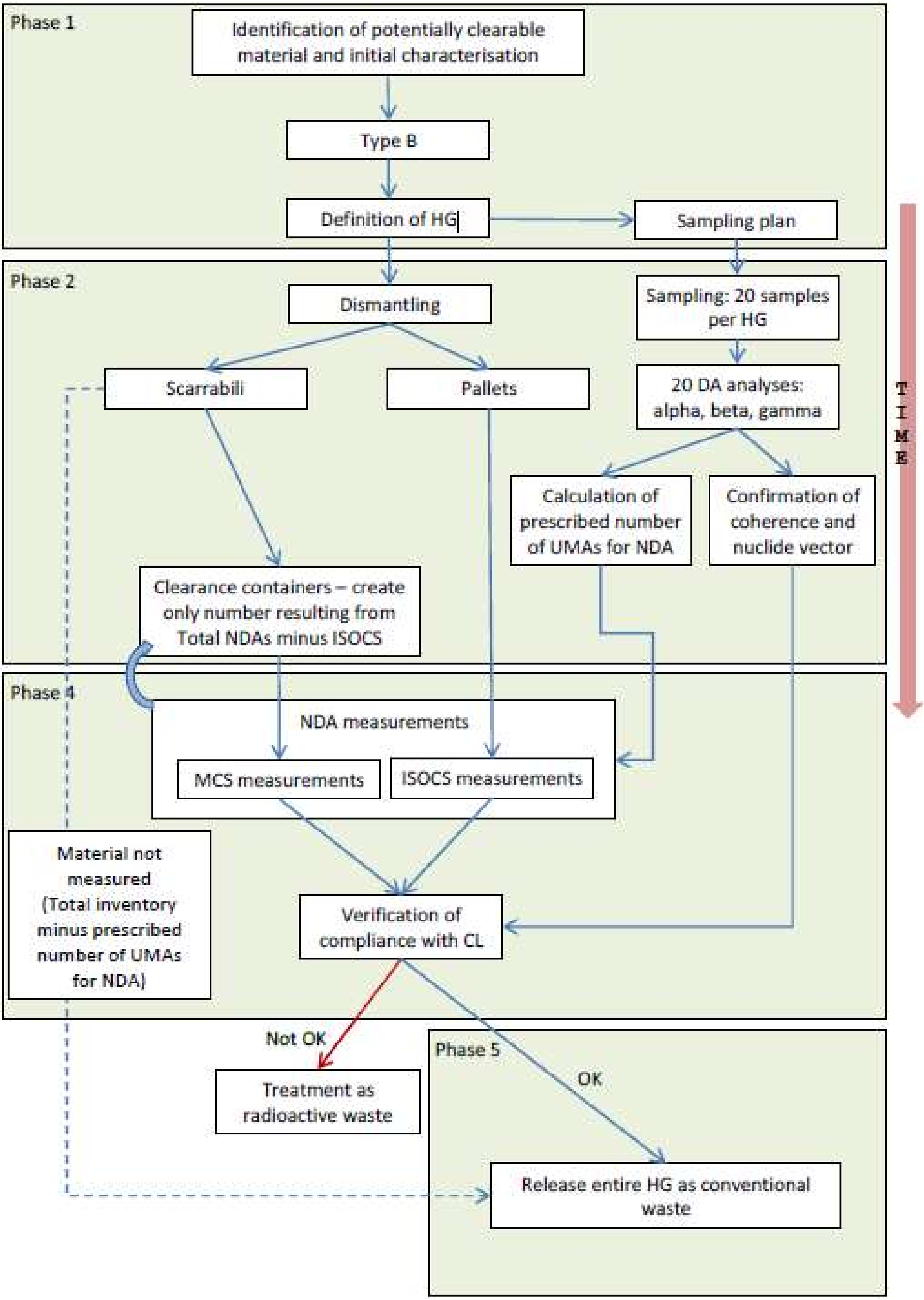

Figure 6: Graphical representation of the possible improvement of the clearance process

3.3. Reduction of Number of Minigroups

The definition of the homogenous group also included segregation by system. Consequently, a high number of homogenous groups was defined (57 homogenous groups). This was later reduced to 4 homogenous groups (to reduce costs and delays related to destructive analyses) and 57 mini-groups [8], created to anticipate the possible split into subgroups if the big group does not pass the homogeneity test.

These four homogeneous groups (HG) were:

1	Group 1: Depleted Uranium-Metallic (257 UMAs)	3	Group 3: Depleted Uranium – Other materials (151 UMAs)
2	Group 2: Depleted Uranium-Cemented Materials (3 UMAs)	4	Group 4: Depleted Uranium and Fission products – Other (42 UMAs)

To follow up on the recommendation made in 3.23.2, it is suggested to reduce drastically the number of mini-groups (i.e., allow mixing of material of certain mini-groups). As it is said in 1.1.3, in case the homogenous group proves to be not homogenous it must be subdivided into subgroups (as a consequence of the evaluation of destructive analysis results).

The reduction of homogenous groups might cause cross-contamination and hinder the division of materials

TIP: A reduction of the number of mini-groups enables dismantling in big pieces to be put into bigger containers **to prevent cross-contamination and simplify the process.**

The proposed reduction of mini-groups should **retain the risk minimisation logic** and only allow mixing materials with similar contamination risk. Details of a possible reduction of minigroups are provided in Section **¡Error! No se encuentra el origen de la referencia.** below. The Clearance Advisor must assess this proposal.

3.4. Type D Reclassification

Some contamination was found on cables (Type D), and Salvarem workers became lightly contaminated during field inspections in presumably clean areas [6]. The source of this contamination has been traced to the event described in the Historical Site Assessment Report [7]: "On the 29th of July 1992, during a pressurisation test of TERMOS tank (L-08 test), a structural failure of a connection pipe and a discharge of high-pressure steam (dozen of kilos) dragging uranium dioxide particles occurred".

Any site's history of experimental activity **will make it hard to justify the existence of type D material (neither contaminated nor activated).**

It is proposed to reclassify the maximum possible part of the dismantled material in Type D by studying the contamination incident report [10] and preparing an updated and detailed cartography. It is however reminded that for Type D, the monitoring of 10% of UMAs was done to check for the absence of artificial radioactivity and not for compliance with clearance levels. **This decision to check 10% of the Type D UMAs is a JRC proposal, accepted by the Safety Authority, and not a requirement.**

TIP: It may be interesting to reclassify class D material into class B material.

Therefore, any measurable amount detected there, even far below the clearance levels, would mean reclassification back to Type B.

In addition, the requirement on minimum detectable activity for Type D was one order of magnitude below the clearance levels while for Type B it is sufficient to demonstrate compliance with clearance levels. For instance, the minimum detectable activity for Type B is the same as the clearance levels. So far, the measurements of panels at level 0.0 m have demonstrated the ability to achieve MDAs (minimum detectable activity values) only at approximately ¼ of clearance levels.

3.5. Material evacuation

Containers must be monitored for the absence of any contamination on external surfaces, **sealed** by adequate measures **and checked** for compliant contact dose rate, but these measures might not be efficient and cross-contamination can happen.

There is a risk of cross-contamination in filled clearance and buffer storage containers

TIP: Perform an early evacuation to a supervised area

3.6. Dismantling Procedure Schedule

Samples for destructive analyses were taken as the first dismantling action in each room. For the time being (end of June 2013), 14 samples were done, and 49 remain. However, **some samples can only be taken during dismantling** (such as samples to be taken in the furnace).

Therefore, cutting and packaging are performed in the FARO dismantling project without knowing the number of segregated UMAs that must be made available for non-destructive analysis measurements. The **logic adopted for cutting, dismantling, and packaging** is as outlined in the Salvarem detailed design ([8], [9]):

1	**Small-size loose items** that do not need disassembly can be collected into clearance containers.
2	**Bigger loose items** are kept on pallets.
3	The use of big bags was abandoned for their deformation when complete. Whatever was initially planned for packaging in big bags is being collected in clearance containers instead.
4	Potentially clearable material from **small homogenous minigroups** is being cut into clearance containers in anticipation of required clearance containers for material clearance system measurements.
5	Potentially clearable material from **large homogenous minigroups** is planned to be put into scarrabili, from which a random sample clearance container is made, and other UMAs can be retrieved into additional clearance containers when required.
6	Components with a geometry suitable for **in-situ measurements** can be monitored using ISOCS (objects with areas filling the detector's "view range"). Some of them will require (partial) disassembly to enable multiple measurements, for example, when internal surfaces of thick-walled components can be potentially contaminated.

This logic needed to be rescheduled **having identified the bottlenecks which delay the process** (delays in waiting for results of destructive analysis, non-availability of the material clearance system (the computer operating Material Clearance System is broken down and the maintenance contract with the material clearance system supplier has expired; SGRR is trying to fix the problem via Lot 3 Contractor), ISOCS measurements, non-availability of buffer storage in Room 021).

> Delays were related to destructive analysis, non-availability of the **instrumentation and buffer storage, and In-situ Clearance System measurements.**

Some actions that could be made are:

	TIP 1: Disconnect the dismantling activities and the clearance process This means having the clearance activities out of the dismantling critical path
	TIP 2: Finalize the general cartography, and the sampling plan immediately and put it at the disposal of the buffer storage
	TIP 3: Realize the complete destructive analysis sampling
	TIP 4: Send the sample to Envinet, requesting an acceleration of the analysis, in parallel with the updating of the Detailed Design
	TIP 5: Procure the "buffer containers"
	TIP 6: Fix the measuring issues (see here after the lesson learnt as to the ISOCS process)

3.7. Depleted Uranium Measurements

Depleted uranium is challenging to measure using JRC ISOCS equipment with sufficient sensitivity. Initially, lightweight **Type B** panels from separation walls have been measured on the level 0.0 m, tackling a high background issue and only with 16-hour counting time the minimum detectable **activity has achieved desirable values below the clearance levels**.

However, for type D material, if the measurement equipment is either a Measurement Clearance Station or an In-situ Counting System, its sensitivity might be insufficient to achieve MDAs (Minimum Detectable Activity Values) of one order of magnitude below clearance levels.

On another note, **the necessity of long measurement times by ISOCS on depleted uranium is currently one of the bottlenecks.**

TIP 1: Lower background may reduce the measurement acquisition times necessary to achieve the desired low minimum detectable activity.

Until the clearance process is successfully finished, the components must be under contamination control measures (i.e., stay in the Controlled Zone or placed in a filtered ventilated SAS) or they have to be hermetically wrapped before their release into the Supervised Area.

TIP 2: Establishing a measurement room in the supervised area and transferring wrapped components between the controlled zone, this room, and a buffer storage area

Other methods of improving the sensitivity of measurements need to be investigated - better detector for ISOCS (ideally low energy germanium (LEGe) detector with beryllium window), local shielding made of lead bricks, or even use of luminescence-based detection of uranium (currently not considered in the clearance procedures).

4. RECOMMENDATIONS FOR OPERATORS IN THE EU

This section aims to suggest a new approach to the design phase of clearance processes in decommissioning projects. Economic and managerial results are just illustrative since they are specific to the FARO dismantling project. They are presented to show the strong and weak points of the new procedure proposed.

4.1. Benefits of the New Approach

Regarding FARO, the detailed design (basis of the contractual arrangement) identifies the amounts of potentially clearable material to be dismantled as:

- Put on **pallets**: 54 t
- Put in **scarrabili**: 42 t
- Cut and put into **clearance container**: 33 t

The assumptions used in the new approach are:

1	The references used are the Salvarem's documents and the WP contract.
2	**Containers**: If the loading factor for scarrabile and clearance containers is identical, the amount of material in 1 scarrabile is equal to that of 40 clearance containers.
3	**Dismantling staff**: the same number of workers is considered for the analysis.
4	The remaining quantity of material to fill in a clearance container is **27 t** (after 6 t of material have already been cut into 28 clearance containers)

<u>**Containerization Expenses**</u>

With experience from FARO, the average weight of material in a clearance container is 220 kg. Scarrabile would hold 8800 kg. But with disassembly only, the loading factor of scarrabili will be much lower.

- Cost of scarrabile: € 6500
- Cost of clearance container: € 40

Therefore, **container savings** could go up to € 4 500. The difference is insignificant, considering that the containers are reusable in future projects.

Table 2: Containerization expenses

	Into Scarrabili	Into CCs
27 t of material in FARO	*4 (optimistic)* *7 (realistic)*	*125 (realistic)*
Cost of containers	*7 x 6500 = € 45 500*	*125 x 400 = € 50 000*

Cutting Costs

The first approach shows that the cutting in small pieces, allowing the disposal in a clearance container is estimated at 39 man-hours per tonne, corresponding to 9.7-man days per tonne.

The cutting is to be done in the containment by workers completely equipped with PPE (including Tyveks, masks and the associated accessories), the maximum possible cutting time is estimated at 4 hours per working day. (See 3.1).

The total potential gain for 27 t of material equals 27 x 14.2 = 264 man-days which may be potentially deducted from the total cost of the dismantling.

The current breakdown cost, determined at the end of June 2013 shows that the pure dismantling is scheduled to be performed by March 2014 for a duration of 230 working days, mobilizing a staff of 4 operators (4 man-days per working day) and an overhead staff of 4 individuals (for a total of 0.8-man day per working day). On this overhead, only the direct project hierarchy (foreman) workload is impacted (0.5 man day per working day). Hence, considering that there would be a total dismantling staffing of 4.5 man-days per working day and an initial total workload was estimated at 729 man-days, a preliminary analysis shows that:

The final workload after modification shall remain 729 - 264 = 465 man-days (the total potential **gain in productivity is 36%**)

The duration of the dismantling is reduced by 264/4.5 = 58 working days (**11 weeks**)

Table 3: Cutting alternatives [12]

Example System	Into Scarrabili	Into CCs
Pipe of 20 m	*3 cuts*	*20 cuts*
Ventilation ducts	*Disassembly in 5 m long sections*	*Disassembly in <1 m long sections and longitudinal cut*
Platforms, stairs…	*Disassembly only*	*Multiple cuts*

Other comments about the benefits of the new approach are:

- Scarrabili containers **cannot be placed at level -6.50** due to the size of the hatch. They must be stored in room 021, waiting for the results of the clearance process.
- The final expected possible gain will have to consider expenses due to the following:

1	The wrapping of the deconstructed material
2	The purchase of closed-in buffer storage containers fitting with the size of the hatch and possibly other expenses in line with the (unfavourable) results of the destructive analysis
3	Retrieval of the deconstructed material from the scarrabili
4	Un-wrapping of deconstructed material
5	Installation of a cutting shop
6	Procurement of CC containers (maximum € 50 000). This is not a real constraint, as they can be reused

4.2. Risks of the New Approach

Poor homogeneity of homogenous groups – high demand for non-destructive analysis

This risk is realistic because the results of the destructive analyses are unknown. However, it is not a binary risk (yes or no) but a decreasing risk, see Figure 7.

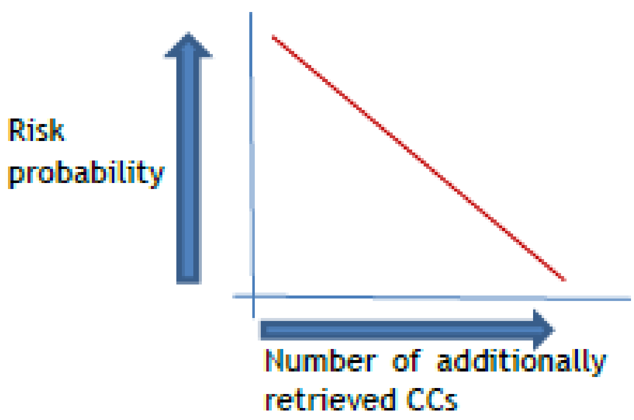

Figure 7: Risk Probability-Number of additionally retrieved CCs correlation

The retrieval by Salvarem of additional material from scarrabili and its fragmentation into clearance containers is the worst retrieval case of all 27 t. The fragmentation itself is already anticipated in the current WP. Hence, the extra cost is retrieval from scarrabili and transfers to a cutting shop to be installed, which is intuitively much lower than the fragmentation costs.

Non- homogeneity of homogeneous groups, a mixture of radioactive waste and potentially clearable

Risk is low and material tracing will be performed even for loading into scarrabili – we will know which UMAs are in the scarrabile, even if we cannot distinguish one from another.

The worst case is having to declare all 27 t of material as radioactive waste. The penalty would be retrieval by Salvarem of the material from scarrabili and its fragmentation into 200-litre drums plus costs of super compaction plus costs of CP-5.2 plus costs of disposal.

5. SUMMARY OF ACTION ITEMS

Figure 8 aims to summarise the main hurdles other organizations may encounter during the preliminary activities in any clearance process and the actions proposed to overcome them.

Figure 8: Comparison of action/s proposed to confront the main hurdles in the project

Area of Application	Hurdle to Overcome	Proposed Action/s
Special Clothing in Site	Productivity Limitation	Organise work in shifts
		Review the need of full masks
		Masks only for preparations of opening
DA Sampling	Time Consumption	Stop Production of CCs by fraagmentation in small pieces
		Deposit as bit as possible pieces directly into scarrabili
		Masks only for preparations of opening
Number of Minigroups	Time Consumption	Allow mixing of material of certain minigroups
Equipment Checking	Time Consumption	Cancel Double Checking
Material Classification	Sensitivity Defficiencies	Re-classify Type D material by studying the contamination incident report and prepare an updated and detailed cartography
Material Evacuation	Cross-Contamination	All the material coming out from the clearance process as "conventional" can be put at disposal of a scrap merchant, charge to him to evacuate, sort and valorize the material
Containment	Costs Defficiencies	An opportunity is to analyse if savings can be made by keeping large components uncut aand placed into ISO containers
Scheduling	Time Consumption	Disconnect the dismantling and clearance process
		Complete the DA Sampling
		Request an acceleration of the analysis
		Fix the measuring issues
		Finalize the general cartography, the sampling plan the disposal of the buffer storage as sson as possible

6. CONCLUSIONS

6.1. Executive Summary

Both recommendations and lessons learned in this document touch on essential topics in any engineering project: **safety, costs, and time**. This report explains how some discouraging results were found after the original methodology was implemented. These outcomes reflected some inefficiencies that contradicted how practices should be carried out in future clearance processes.

Lessons learned revealed possible improvements in **time management**. Samples of destructive analyses were taken as the first dismantling action in each room. Therefore, **cutting and packaging** were done without knowledge of the quantity of UMAs necessary for non-destructive analysis measurements and this caused great delays in the process. The report suggests **destructive analysis sampling and analysis should be done as early as possible** due to the minimum processing time of 3 months until the results are received. Reducing this waiting time will **enable processing and calculating the number of non-destructive analysis measurements before the dismantling is finished.** It would also be possible to prepare only the exact number of additional clearance containers since UMAs on pallets will be measured by ISOCS and several clearance containers will be already prepared.

Depleted uranium is also considered excessively time-consuming due to the lack of sensitivity in their measurement using ISOCS equipment, especially for Type D material. Lower background **may reduce the number of measurements required** to achieve low MDAs. For this reason, the study suggests establishing a buffer storage area and a measurement room to transfer wrapped material through the controlled zone. Also, it is possible **to avoid identified bottlenecks** by modifying the logic of the works.

Practices learned throughout this report include activities like the **prevention of cross-contamination** or the modification of procedures that will improve the safety and environmental results of future decommissioning projects that use this knowledge product. Also, **reducing the number of mini-groups** is proposed to retain the risk minimisation logic and only allow mixing the material with similar contamination risk.

The report recommends a new approach to **modify the process design**, which is explained in Section 4. This new methodology is expected to produce a **cutting costs reduction as well as a gain in productivity.**

6.2. Importance of Capturing These Practices

This technical report helps to share the experience obtained throughout the first activities in the FARO dismantling project I-04-05-01. These activities include the characterization, design, and the start of the deconstruction practices of the project. Due to the lack of experience in this kind of project, the lessons learned in this report add value to future JRC's decommissioning activities. This knowledge will also benefit users such as operators and regulators outside the JRC program.

7. REFERENCES

[1] D.Lg. 230/1995 e aggiornamenti successivi Attuazione delle direttive 89/618/Euratom, 90/641/Euratom, 92/3/Euratom e 96/29/Euratom in materia di radiazioni ionizzant.

Available Online:

chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.sardegnasalute.it/documenti/9_463_20160601152137.pdf

[2] UNI 11458 2012: Metodi e procedure per il controllo radiologico ai fini dell'allontanamento.

Available Online:

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://iris.enea.it/retrieve/dd11e37c-dba2-5d97-e053-d805fe0a6f04/IRP-P000-010_Rev1.pdf

[3] 'Letter of Italian Ministry of Economical Development IMP/26 from 25/07/2008 and its later amendments on Conversion of Nulla Osta Category A'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[4] 'NE.81.2607.A.002 Rev. 0: Procedura generale per la gestione delle attività di allontanamento dei materiali'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[5] 'NE.80.2625.SR.001, Rev. 0: Waste Acceptance Criteria: Overview Document'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[6] 'NE.40.2220.SR.001, Rev. 0: Waste Management Plan for FARO Dismantling Project'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[7] 'NE.16.2223.IB.001 Rev. 0: Historical Site Assessment Report – FARO'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[8] '110 149 NT 05, Issue D: FARO DISMANTLING WORKS – SCHEDULE – WASTE FLOW'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[9] Hervé Boisseau, 'Spreadsheet Homogeneous groups & wastes 130129_following VST review.xls'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[10] 'NE.83.2607.A.003, Rev. 0: Campionamento, caratterizzazione e verifica radiometrica di materiali solidi dismessi ai fini dell'allontanamento'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[11] 'NE.83.2228.AR.001 Rev. 0: Azioni di Radioprotezione in FARO in supporto alle attività di smantellamento'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu

[12] '110 149 NT 07, Issue A: Technical Note (Impact on Project of MCS sampling)'.

Available in JRC Directorate J's Archive, available under request to Andrea.PIAGENTINI@ec.europa.eu