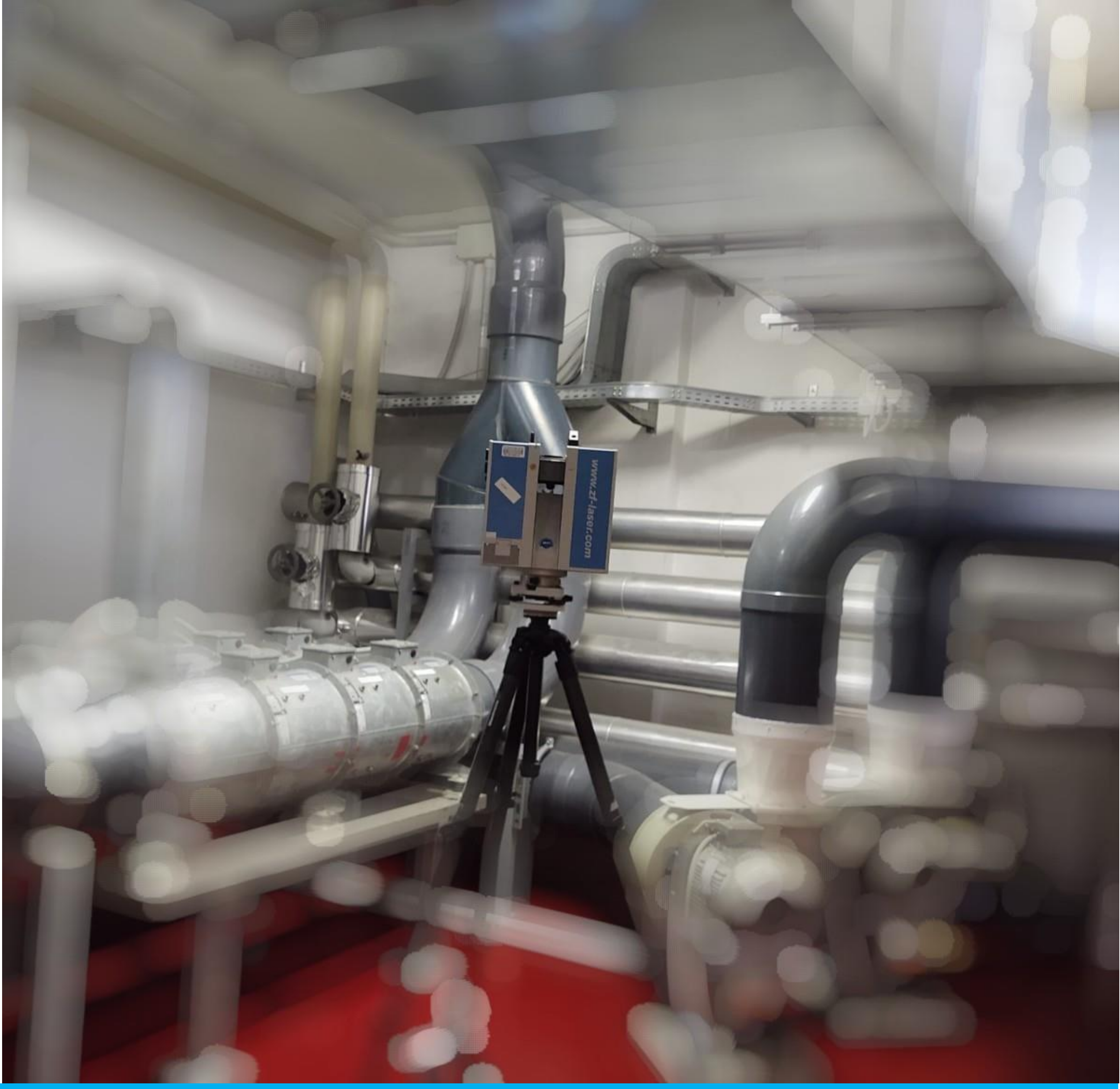


3DIMS Development and Operation

Experience Report

KP-NUVIA-001

24/07/2023

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 NUVIA Process for the JRC NDWMD.

<table>
<tr><td>Document code</td><td colspan="4">KP-NUVIA-001</td></tr>
<tr><td>Performed by</td><td colspan="4">Vladan STEFULA</td></tr>
<tr><td>Revised by</td><td colspan="4">Francesco RAIOLA, Xavier JARDÍ, Luis Felipe DURÁN and Laura MARTÍN</td></tr>
<tr><td rowspan="3">Version</td><td>V0</td><td>09/05/2023</td><td colspan="2">Draft version</td></tr>
<tr><td>V1</td><td>26/06/2023</td><td colspan="2">First round of comments incorporated</td></tr>
<tr><td>V2</td><td>24/07/2023</td><td colspan="2">Approved for issue</td></tr>
<tr><td>Sent to</td><td colspan="4">Andrea PIAGENTINI</td></tr>
<tr><td>Approved by</td><td colspan="4">Knowledge Management Officer</td></tr>
<tr><td rowspan="2">Taxonomy domain</td><td colspan="2" rowspan="2">Decommissioning</td><td>Decommissioning, Preparation</td><td>Decommissioning planning</td></tr>
<tr><td>Characterization</td><td>Facility characterization</td></tr>
</table>

[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

This knowledge product has been identified by the Decommissioning Knowledge Management (DKM) Team Leader in the technical specifications for NUVIA Process activities in 2023. It forms a part of the suite of the Knowledge Products (KP) under the DKM Initiative.

This product describes personal user experience with a specific software called 3DIMS (3D Information Management System). Development of 3DIMS and its operation are explained by the author who has witnessed the discussions between 3DIMS client, i.e. Nuclear Decommissioning and Waste Management Directorate (NDWMD) of JRC and the team of developers in another Unit of JRC. At the same time, the author is also the most frequent and hence most experienced user of 3DIMS.

This KP is focused on practical applications of the 3DIMS software rather than comprehensive itemised description of the software features. Examples are included how 3DIMS was really used during an engineering work for nuclear decommissioning.

It is this user experience which is the main knowledge intended for sharing with other current less experienced and future users of 3DIMS within JRC or even outside. Future users can and should consult the User Manual available in JRC Intranet [1], but this present knowledge product is more focused on what can 3DIMS be useful for rather than “how to” do it.

ABSTRACT

The document offers “all-in-one-place” information about 3DIMS (3D Information Management System) software package which was introduced to the computers of JRC in March 2019. It starts with some contextual information about the birth of 3DIMS, it provides practical guidance for everyday use and quick navigation as well as several examples of how 3DIMS is practically used for engineering work in nuclear decommissioning. Finally this present report outlines which features and applications can improve this product and add further value in future.

Useful tips for effective use and real benefits of this software package are highlighted throughout this document. The reader will benefit from abundance of screenshots accompanying the described examples and features.

OBJECTIVE

The main objective of this experience report is to enable the target user with the minimum actionable knowledge to develop competencies in the 3DIMS software and to promote use of this new digital tool born in JRC for support of decommissioning planning and engineering activities also outside of its place of birth.

APPROACH

This product is presented in the form of an experience report to quickly capture the first insights and experiences of users at JRC-Ispra site. The knowledge gained by the project team is still new and not profoundly absorbed nor structured yet the lessons learned so far are worth sharing in this format. With the approach of following the examples presented in the experience report, current and future users of 3DIMS will get more interesting and attractive training than the one provided by following the User Manual [1].

RESULTS, FINDINGS, AND INSIGHTS

This KP finds 3DIMS to be a valuable tool, although its users base is currently sparse. There are many benefits in use of 3DIMS for nuclear decommissioning engineering work, namely:

- Work efficiency gain
- Time savings
- Dose savings
- Remote dimensions measurements
- Components geolocation
- Obstacles identification
- Continuity of pipes
- Improved traceability
- Radiological information visualisation
- Dismantling progress visualisation

TARGET USERS

The primary beneficiaries of this knowledge product are engineers and managers from NDWMD and Contractors who are familiar with MIRADIS (JRC-Ispra database of components and radiological properties) WITS (JRC-Ispra database of waste objects created in decommissioning) or at least who know exactly what MIRADIS and WITS serve for, but who are not yet familiar with 3DIMS.

This knowledge product is by no means intended as publicity for sales of 3DIMS to other decommissioning operators. It aims to capture its general advantages for decommissioning planning and it is applicable to any other similar system of scanned 3D information management.

APPLICATION, VALUE, AND USE

The benefits of using 3DIMS include more effective collaboration, faster access to data sources and saved dose to personnel. The knowledge described here can be immediately transferred to engineers and managers from NDWMD and Contractors. Other stakeholders of the EU can benefit from these lessons learned only indirectly by introducing a similar system for 3D information management.

KEYWORDS

Decommissioning, Preparation, Decommissioning planning, Characterization, Facility characterization

TABLE OF CONTENTS

LIST OF ACRONYMS AND DEFINITIONS

3DIMS: 3D Information Management System

6DOF: 6 degrees of freedom

AR: Augmented Reality

ADECO: Name of hot laboratory

BIM: Building Information Management

EC: European Commission

ESSOR: Name of reactor in Ispra

INE: Nuclear Plant ESSOR

JRC: Joint Research Centre

KP: Knowledge Product

MIRADIS: Name given to the ESSOR nuclear inventory database

MLSP: Mobile Laser Scanning Platform

NDWMD: Nuclear Decommissioning and Waste Management Directorate

PERLA: Performance Laboratory

RER: Radiation protection Events Registry

ROI: Region of Interest

STeAM: Sensor Tracking and Mapping

VR: Virtual Reality

WITS: Waste Information Tracking System

LIST OF FIGURES

1. 3DIMS OVERVIEW AND CONTEXT

1.1. Historical Context

The decommissioning of JRC-Ispra nuclear site is a very long project spanning 4 decades. In addition it involves 8 diverse nuclear facilities which had long of years of operation and shut-down after operation. Not rarely, additional structures were added or existing structures modified. Along with such a site, a large number of documents comes in form of design documents, both on paper and digital, 2D and sometimes 3D, legal documents, and so forth. Practically, the site status today cannot be easily represented only with this information and as-built information cannot be easily retrieved from the Archive data.

In very generic terms, each nuclear decommissioning project starts with a set of radioactively contaminated components and finishes with a set of radioactive waste packages. All the physical and radiological information associated with components has to be converted into information associated with radioactive waste packages while maintaining complete traceability and eventually ensuring 300 years of record keeping during institutional control period of the radioactive waste repository.

All these considerations lead us to search for a digital solution ensuring we work with up-to-date information, seamless traceability and long-term record keeping. These in our minds could be achieved by implementation of an overarching decommissioning database. This mental picture was visualised in the promotional multimedia short film “Nuclear Decommissioning Story by aNDy”[3] as a constantly evolving cube made of smaller cubes interacting with the decommissioning project.

3DIMS was born as such a “small cube” of the overarching decommissioning database: a database of 3D scans representing as-built status of the plants. Trial stage scanning started in our major nuclear facility, ESSOR reactor, since 2015 while discussions about software implementation also started between the Nuclear Decommissioning and Radioactive Waste Management Unit of JRC and a research unit located at the same site of Ispra.

Digital planning tools exist to describe status and progress of the structures under construction. These tools are called Building Information Management (BIM) and use a combination of documents, tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of the construction. The digital representations are then transferred to reality while maintaining the digital twin constantly up-to-date. Final goal of BIM usage is creation of the real construction identical to the original digital plan.

Decommissioning however poses an opposite challenge. The real facility already exists, typically with a poor digital representation and it is necessary to re-create it in digital world for purpose of traceability and record keeping. Therefore, modern techniques must be employed to document and maintain an up-to date status of an existing building and its equipment. At Ispra site, such a technique was laser scanning creating the point cloud mesh to get distances and topographical references in the facility.

The conclusions from the discussions between Nuclear Decommissioning and Radioactive Waste Management Unit of JRC and Digital Systems for Safeguards and Non-Proliferation spurred the birth of the 3D Information Management System in 2017 based on a few basic requirements. The informatics system must be flexible to adapt to the corporate needs and restrictions and to be operational for a very long period of time. Commercial alternatives do exist but it is difficult to get guarantees that a system chosen would fulfil the requirements and would maintain product support for the entire duration of the decommissioning project. On the other hand, a tool built in-house can be fine-tuned for specific needs and its modifications and extensions can be implemented as needed. By lucky coincidence the Nuclear Decommissioning and Radioactive Waste Management Unit (customer for 3DIMS) and the group of software developers (in another JRC Unit unrelated to nuclear decommissioning) with in-depth knowledge and key competences in 3D laser scanning, data

[3] aNDy is an animated narrator inside the VR movie. His name is a homonym of ND which stands for Nuclear Decommissioning. See https://joint-research-centre.ec.europa.eu/scientific-activities-z/eu-nuclear-decommissioning-knowledge-management/andy-nuclear-decommissioning-narrator_en

processing and related informatics reside at the same site of EC/JRC Ispra, a fact which facilitated and accelerated the 3DIMS conception.

1.2. Existing Plant Characterisation

For understanding of 3DIMS context, it is also necessary to summarise how physical plant characterisation campaign was concluded at our facilities. The inventory of all components and their physical properties was compiled during 2005-2008 in a database called MIRADIS.

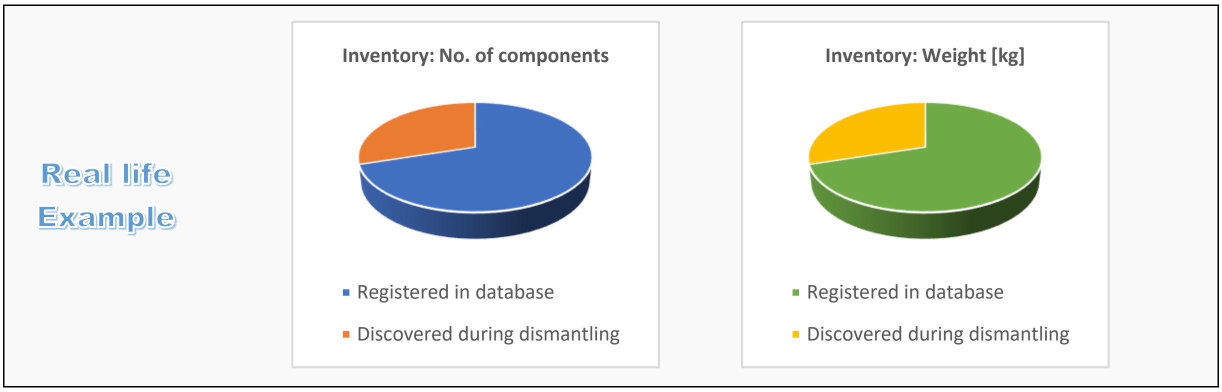
The main method of the components inventory building was the plant walkdown and cataloguing. Catalogued and characterised components were then labelled with MIRADIS tags containing unique 15-character identification codes. There are some problems due to this rudimental method which emerge when using the MIRADIS database data later for planning purposes. First of all, the geolocation of the components is limited to identification of the room. If the room is big and busy with components, it is very difficult to find the component in question.

> ! Traditional geolocation of components is usually limited to the identification of the room. Component identification might need more detailed descriptions, especially if the room is big and busy with components.

Figure 1: Example of a big room busy with components

In a nuclear plant, often two rooms are not segregated by a wall and sometimes it lead to double accounting of the components or application of the wrong room in the component's MIRADIS code.

Finally, cataloguing the components by creating a mental map of components already counted and those waiting to be counted lead during the plant walkdown to frequent omission of the components from the inventory. Actual dismantling experience shows that about 30% of components in one of our facility were not captured in MIRADIS database. Surprisingly, not only 30% of number of components were missed, but also significant portion of total weight was missing in the database. Naturally, one would expect that those 30% of number of components would all be small items easily overlooked and thus forming only small percentage of the total weight. However, the final comparison of the total weight of the components to be dismantled with the weight of the produced waste packages showed that 30% of total weight was missing in MIRADIS.



Majority of our plants have not obtained the decommissioning licence yet and hence the dismantling is to start in future. Therefore, there is still time and mainly there is still need to improve the information about the physical inventory.

1.3. 3DIMS Brief Description

The 3DIMS is an informatics tool to assist maintaining an up-to date description of a large installation. It uses 3D data and images from commercial laser scanners and dedicated software to build and maintain this up-to-date information available to all peers involved in the decommissioning project. In order to enhance 3DIMS use, apart from providing different visualizations of an existing site or building, a number of dedicated add-ons has been introduced to offer various tools and features useful for decommissioning.

Conceptually, the system is composed of three interacting components: (a) the 3DIMS Viewer used by the vast majority of users for their daily interaction, (b) the 3DIMS-3DViewer used for visualisation of the complete point clouds representations of the plants, (c) the 3DIMS Dashboard, used by a limited amount of users, system managers, to add 3D content/images and structure the data, and finally, (c) the 3DIMS database, which serves the previously mentioned front end applications with structured data and content.

The geometrical data can currently be imported from two types of scanners: static and mobile (examples shown in Figure 2). Static devices are very precise scanners using a modulated laser to achieve mm precision in measurement of distances from the scanner in nearly 4π geometry (a small cone is excluded under the scanner where the tripod is). Additionally, to provide a photo-realistic data set, the scanners carry an embedded high-resolution camera. To acquire relevant information from an area with a static scanner, the scanner is placed on the ground using a tripod and an acquisition is performed. When done, the scanner is transferred to a new place that is visible from the previous scan position and the operation is repeated as many times as deemed necessary to cover the area.

Figure 2: Laser scanners enabled to interact with 3DIMS: left – a static scanner, right – a mobile unit

The Mobile Laser-Scanning Platform (MLSP) is a continuous scanning device recording the surrounding environment while being moved through it. It can be carried as a back-pack or mounted on any trolley providing both real-time trajectory (6DOF) and spherical images. A sample of the raw data acquired from a 10 minute walk can be seen in Figure 3.

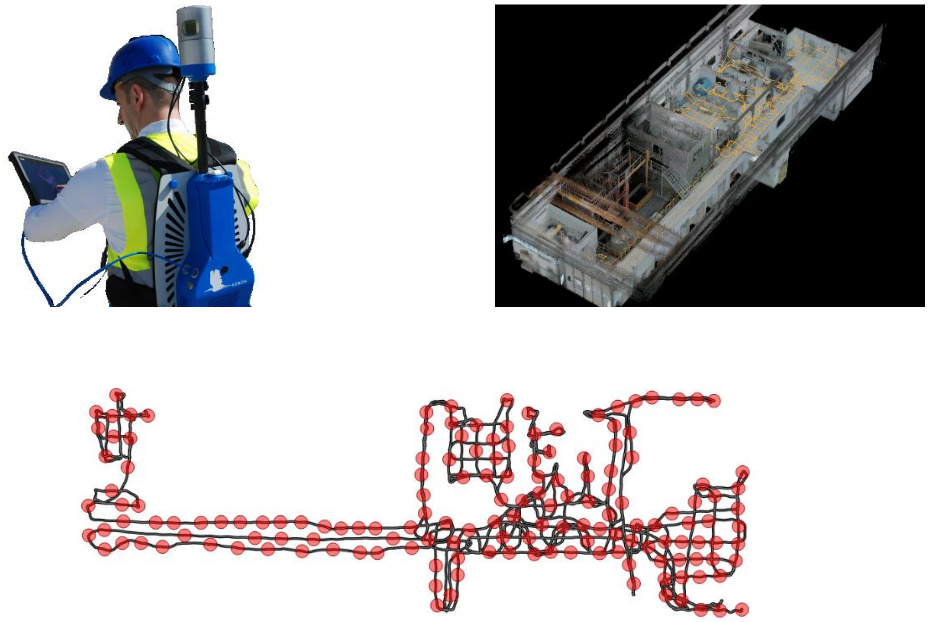


Figure 3: Top left: Scanning using MLSP; Top right: Raw data acquired with back-pack carried MLSP scanner where the orange trajectory is the walk performed, Bottom: Trajectory with circled selected positions of 1 m spacing

Obviously, MLSP offers much higher speed and flexibility of scanning especially within rooms busy with equipment where many static scans would have to be set up for full coverage of the room. Higher speed of acquisition is however paid for by lower points' resolution and photographic image quality. See Figure 4 to compare the difference in the image quality. With some initial experience, it is possible to plan very effective combination of both laser-scanning methods for nuclear plant characterisation campaign.

Figure 4: Part of spherical image with zoomed in detail (Left: Static scanner, Right: MLSP)

2. USER EXPERIENCE

A complete User Manual [1] is available in JRC-Ispra network. The following chapter will provide a different kind of user manual describing the real practical tasks already undertaken by various 3DIMS users.

2.1. Environment or Initial Settings

3DIMS suite is available for JRC PCs upon request to JRC Helpdesk copy to Gunnar.BOSTROM@ec.europa.eu. It can also be installed on a laptop external of the JRC network, but an activation dongle must be inserted into the USB port of the laptop. The dongle can be obtained at the same e-mail address. Activation instructions can also be found in the User Manual [1].

2.2. Navigation

Whatever is the task to be undertaken using 3DIMS, the users have to become familiar with methods of navigation to find the correct scan. As of today, there are 5 separate databases of nuclear facilities of JRC-Ispra. Of course, the first thing to do is to open the correct database of the facility in question (Figure 5). Then there are three methods of navigating through the facility.

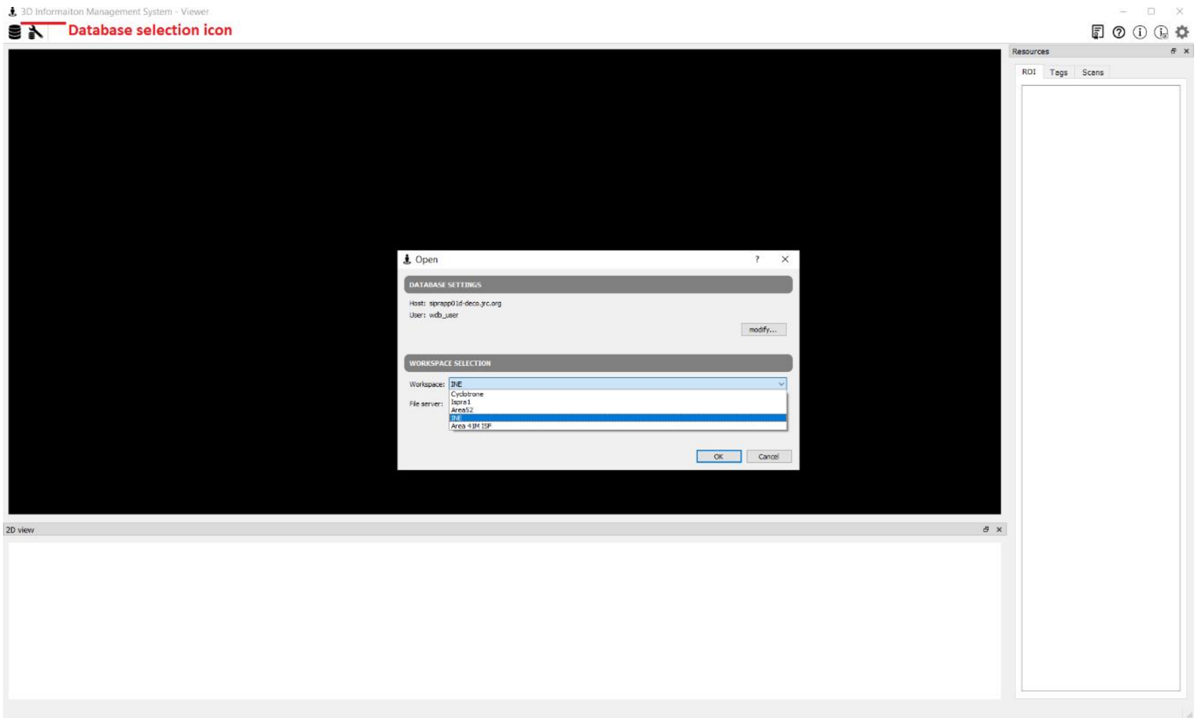


Figure 5: 3DIMS opening screen with database selection (source 3DIMS software)

2.2.1. Streetview Jumps

The first method is equivalent to “walking” through the streets in the Google Maps Streetview. However, in order to jump to the next position, one cannot simply click in the desired direction but has to double-click on a camera icon positioned in the desired direction – see Figures 6, 7 and 8. These figures show how to jump from one view in room 4218 of ADECO (building 83) into another neighbouring view.

Figure 6: 3DIMS view in room 4218 of ADECO (building 83) (source 3DIMS software)

Figure 7: 3DIMS view as in Figure 6 with cursor hovering over camera icon "20180227_Ed83_-6.0m_Loc4218_Scan6" (source 3DIMS software)

Figure 8: 3DIMS view after double-clicking and jumping to the new scanning position “20180227_Ed83_-6.0m_Loc4218_Scan6” in room 4218 of ADECO (building 83) (source 3DIMS software)

There is however a **known bug** in this navigation. Staying at the point where we are in the example and rotating 180°, one can see two camera icons: 20180227_Ed83_-6.0m_Loc4218_Scan2 from where we arrived (Figure 9) and 20180212_Ed86B_Locale2202_Scan1 (Figure 10). One can understand from the file name that the second scan is located in another room and even another building. The explanation of this phenomenon is in the depth information associated with each point in the points cloud. Sometimes the laser scanner is unable to obtain the depth information because of lack of reflection from the point in question. This is true especially for sharp edges of the objects. 3DIMS has a toggle button for switching on/off the depth image – see Figure 11. The points with missing depth information are black in this image. So if a scanning position point in another room beyond the wall happens to be lying on the black point (or black line) of the depth image, 3DIMS software is unable to recognize that there is a wall which should prevent to see that scanning position in normal photograph. These black points in the depth image are effectively “holes” into the photo image.

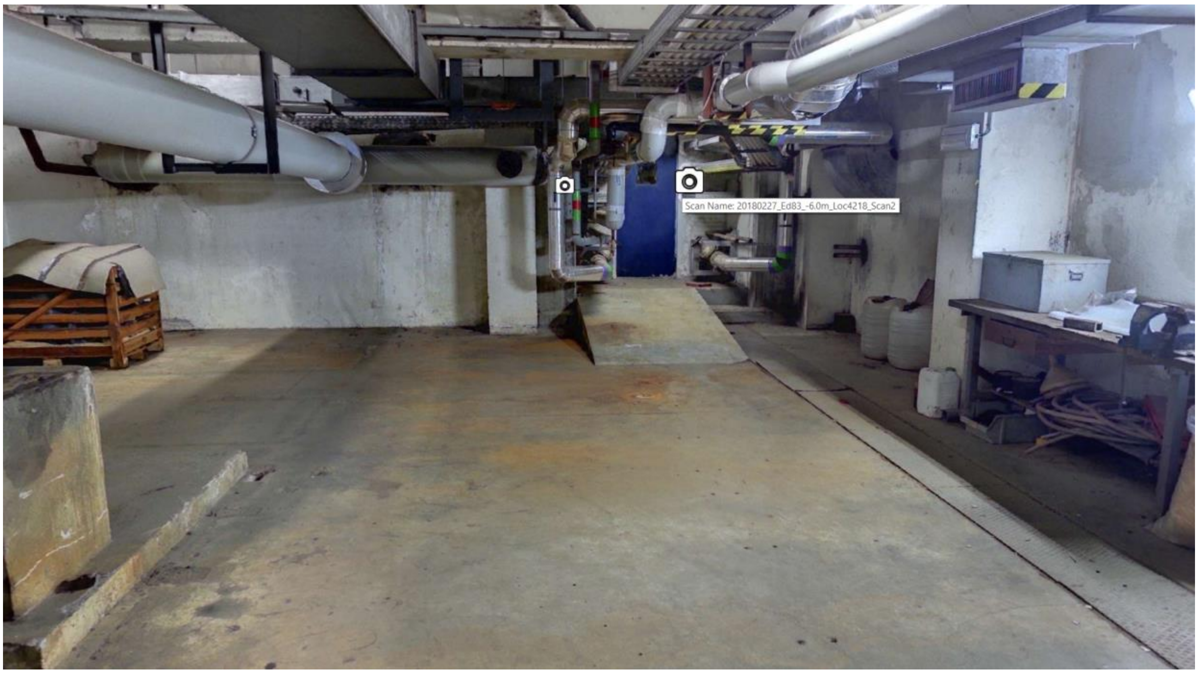


Figure 9: 3DIMS view in room 4218 of ADECO (building 83) seeing back the original position – the text "20180227_Ed83_-6.0m_Loc4218_Scan2" appears under the hovering mouse (source 3DIMS software)

Figure 10: The second camera icon seen from the same scanning position in room 4218 of ADECO (building 83) refers to another room and even another building (source 3DIMS software)

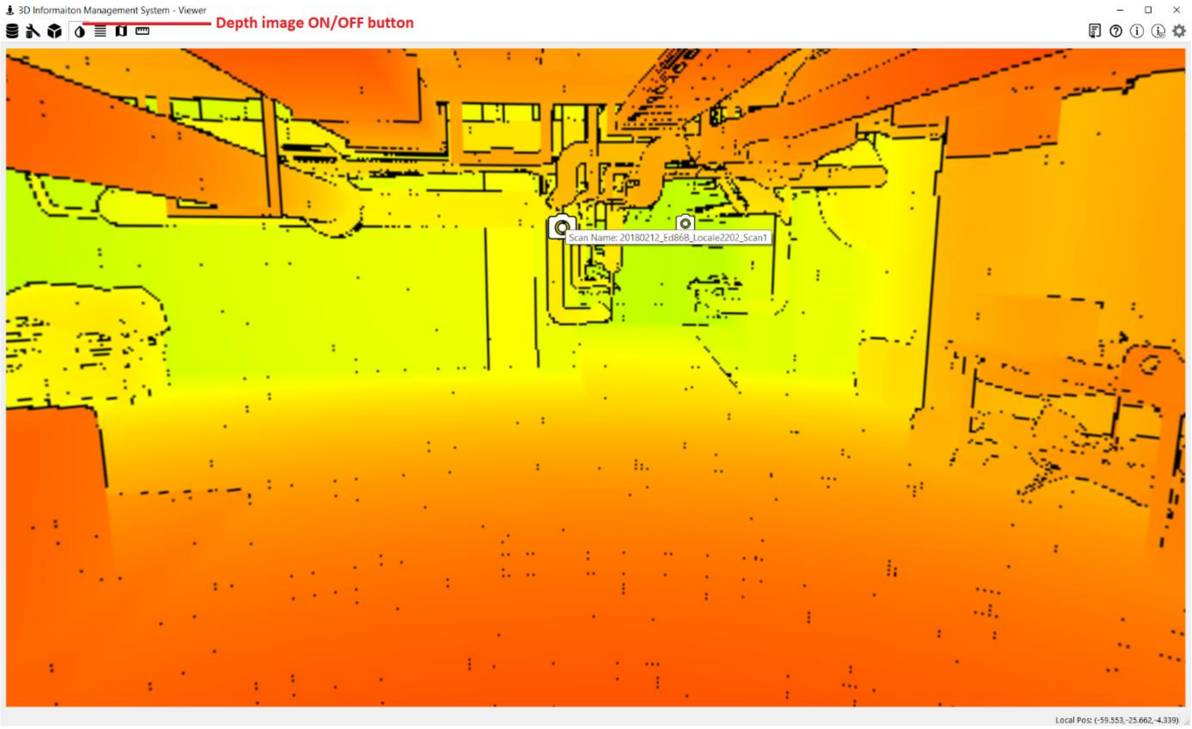


Figure 11: The depth image (activated by the indicated droplet icon) of the same view as Figure 10 second camera icon referring to another room is located on a black line (source 3DIMS software)

2.2.2. 2D Maps

The second method of navigation is simple selection of the scanning point on a classical 2D map. Consult Figure 12 to see how the 2D map pane is activated. It is necessary to clarify that the 2D maps are created automatically by the assembly of the scans and therefore they show only outlines of the features visible to the scanners. More specifically, these 2D maps are not correlated with AutoCAD drawings of the floorplans available in the Archive for all our facilities.

In addition, these 2D maps are “transparent” through all the levels of the facility. Therefore, sometimes a confusion of walls and other features can be seen on the map – see Figure 13.

Big disadvantage of navigation in the 2D maps pane is also the fact that all levels are superimposed one on another so not only the maps contours are superimposed but also the scanning positions of different levels are indistinguishable (Figure 14). Thus, the user must look for correct scan by hovering the mouse over the scanning position which shows the file name. It is the best practice to include the level and room number into the scans’ file names. In this way, Figure 14 was enhanced with colour tags added manually onto the screenshot.

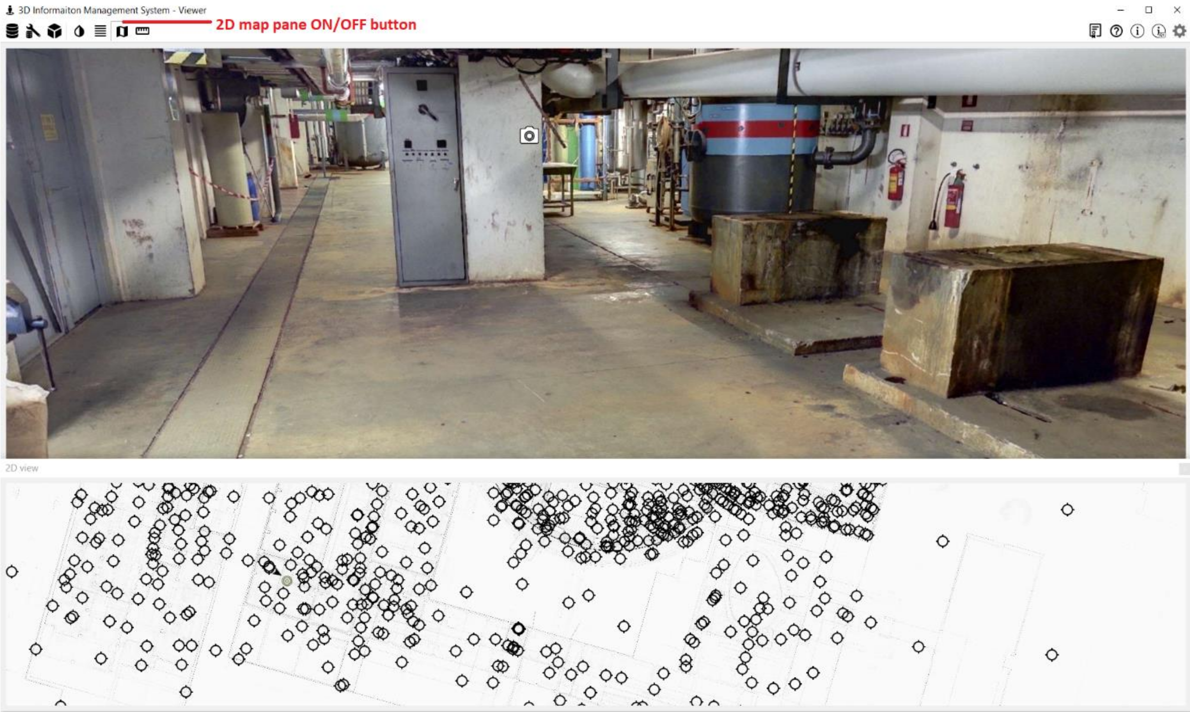


Figure 12: Current scanning position in room 4218 of ADECO (building 83) is identified on the 2D map by a small triangle which is pointed towards the direction where the user is looking (source 3DIMS software)

Figure 13: Example of the confusion created by "transparency" of 2D maps (source 3DIMS software)

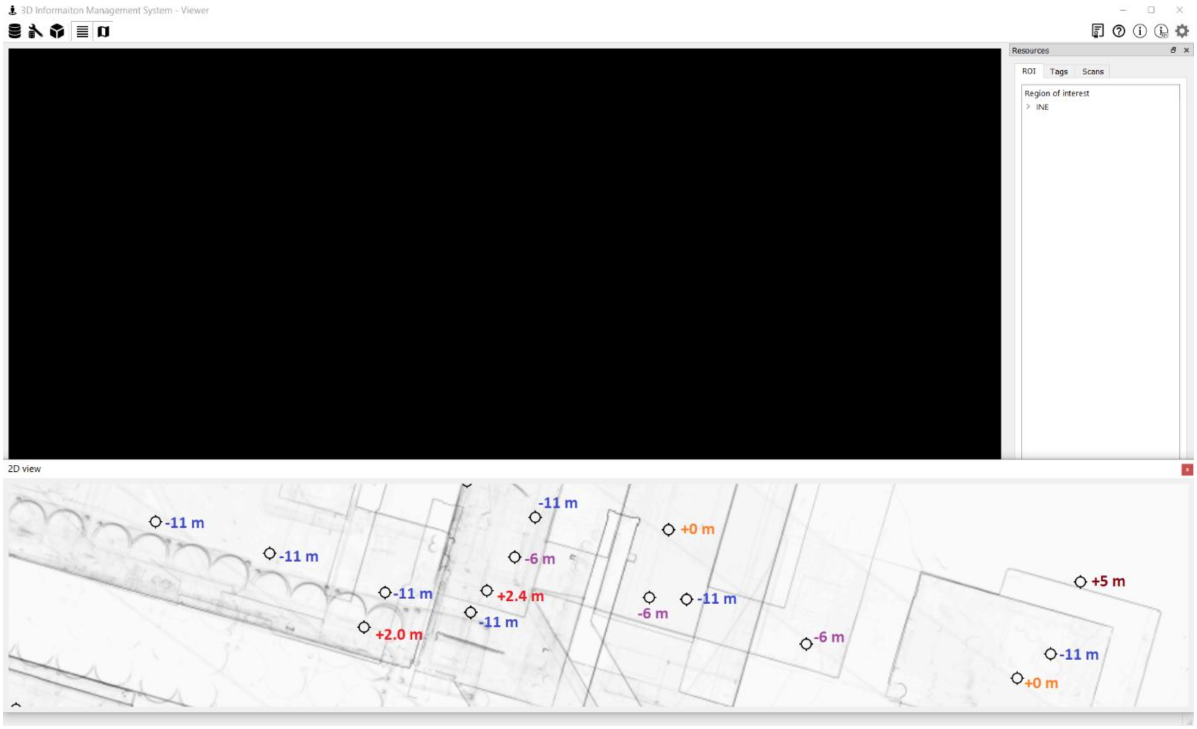


Figure 14: Random zoom on the 2D map of INE where tags of levels have been added manually onto the screenshot but they do not exist in 3DIMS app

2.2.3. Regions of Interest

Many of the problems listed in the second method of navigation by means of 2D maps can be resolved by 3DIMS ability to create hierarchical structures of the scans in the database.

The regions of interest (ROIs) can be found in the Resources pane on the right of the 3DIMS window – see Figure 15. The ROI tab is switched on by default. Here the user can restrict the area of interest in which he wants to navigate but only if the ROI have been (correctly) defined. The hierarchical tree of ROIs in ESSOR reactor building (Building 80) has been very well defined – see Figure 16, but other buildings still need adjustment. This work of ROIs organisation is already in the pipeline of NUVIA Process activities.

We recommend to use regions of interest only under ROI “80 - ESSOR contenitore stagno”. Other ROIs have not been correctly configured so far.

Figure 15: Resources pane and ROI tab of 3DIMS

Figure 16: Complete tree of Building 80 tree of ROIs in 3DIMS

Whenever a ROI is clicked once, the area of the ROI will be delineated in the 2D map – see Figure 17. When the ROI is then selected by double-click, the number of scanning positions in the 2D map will reduce – see Figure 18.

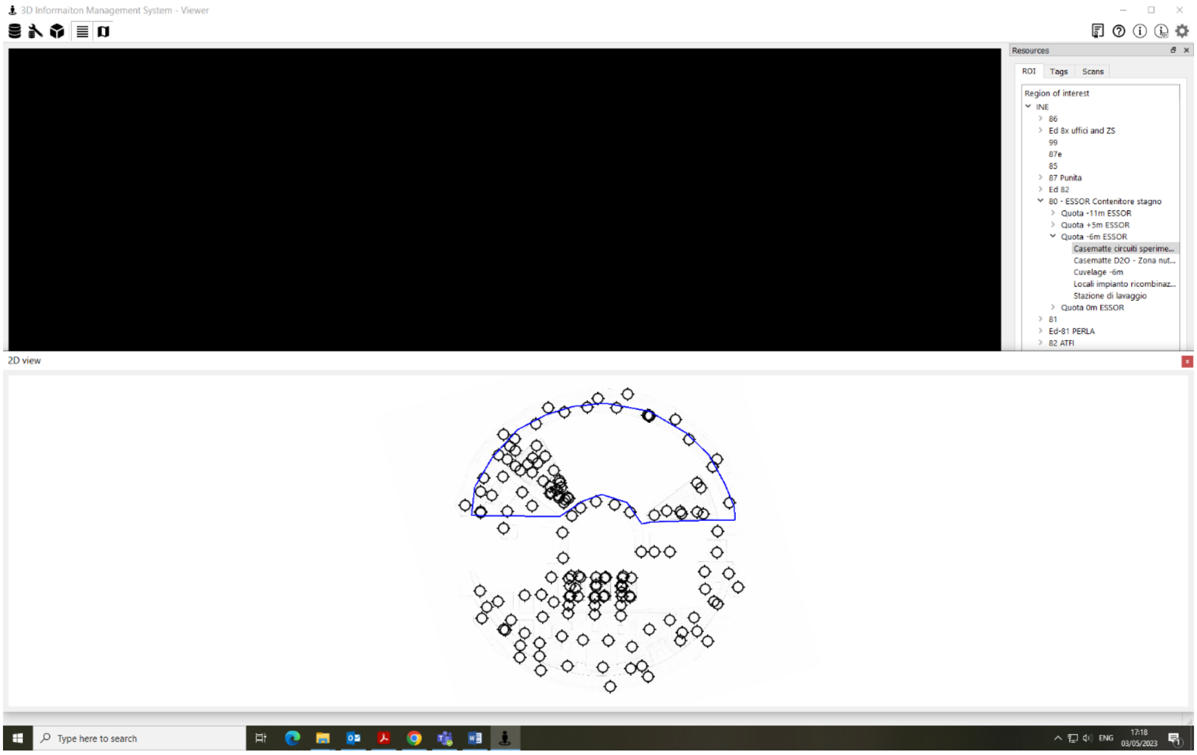


Figure 17: ROI “Casematte circuiti sperimentali” selected by single click in 3DIMS

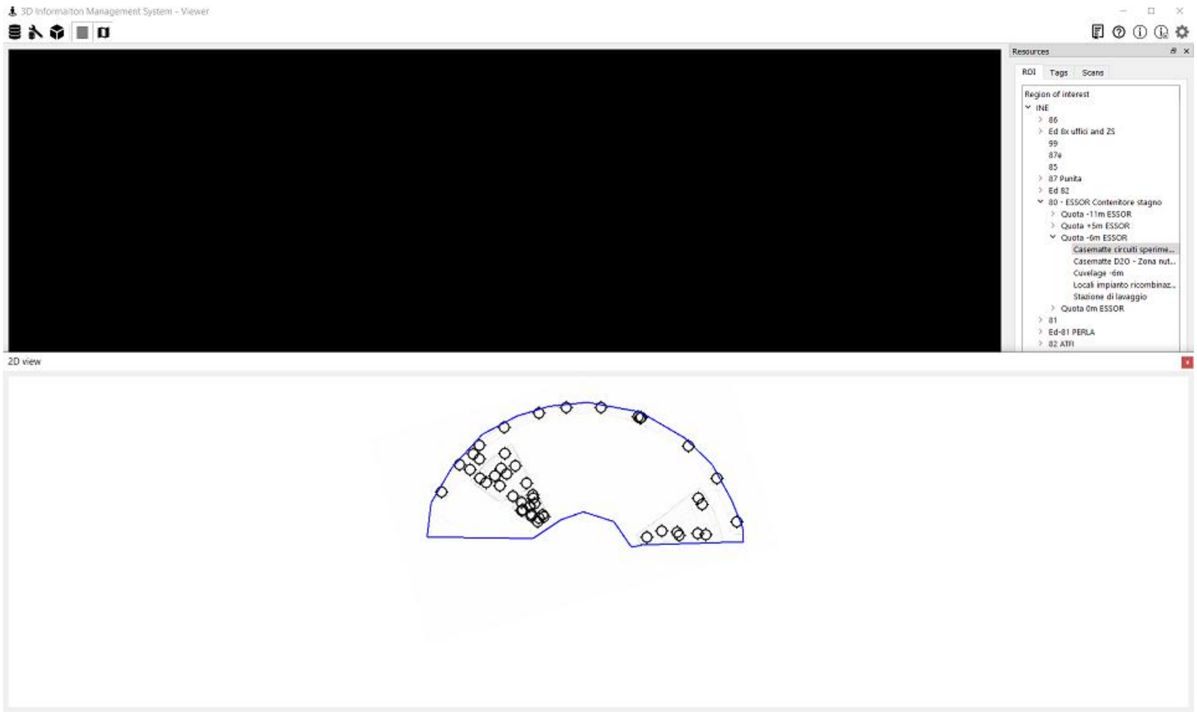


Figure 18: ROI “Casematte circuiti sperimentali” selected by double click in 3DIMS

It is now very easy to navigate between individual scans. The only downside is that at the time of issue of this KP only Building 80 of INE has been correctly segmented into ROIs.

2.2.4. *Scan Names*

Finally, one of the most efficient ways of navigating through the scanned plants is to search in the scan names. To do this, the user must again go to the Resources pane and there click on the “Scans” tab. Generally, the scan names include date of the scan, building, floor and room. Therefore typing into search box of the Resources pane for example “1106” will filter out all 25 scans made in the bunker 1106. One has to be however careful because this filtering will include also the scans which were made on 6th November – see Figure 19.

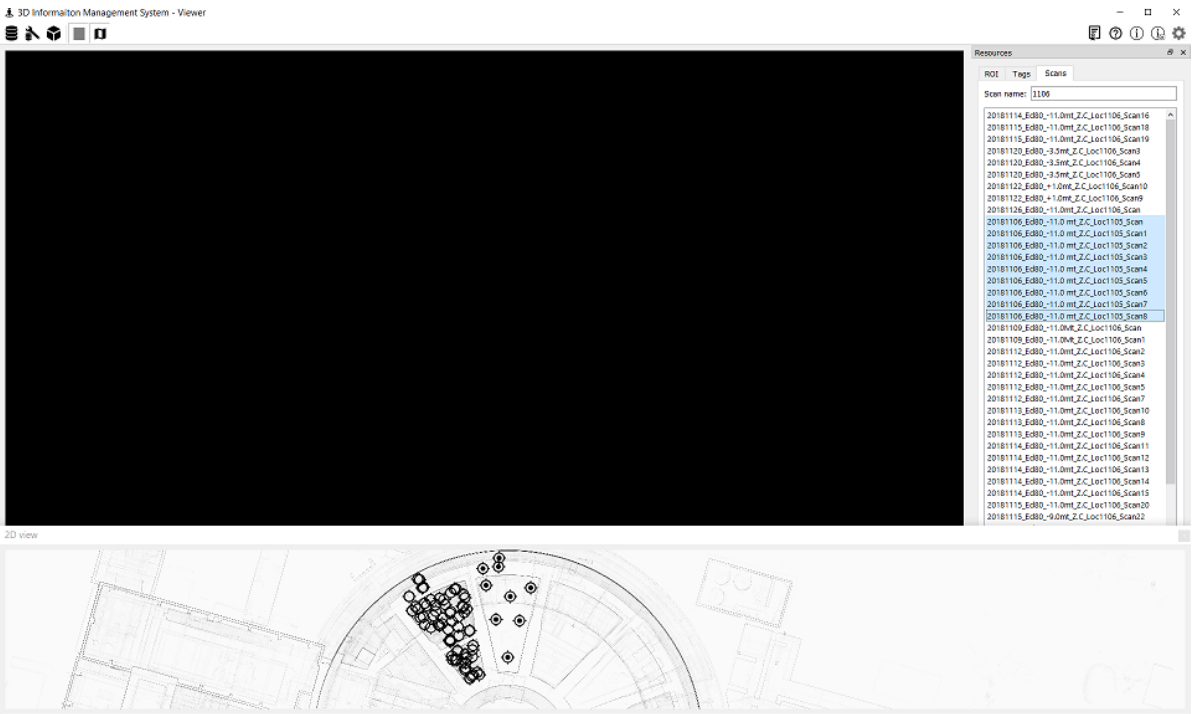


Figure 19: Scans filtered out as containing “1106” in attempt to select all scans of the bunker 1106 in 3DIMS

It should be also pointed out that the first scans were not named with the best practice of using the date, building number, floor and room number, but oversimplified names such as ADECO_# or P_# (for PERLA) were used. A name-changing tool has been requested from the developers to be included in the next release of the system.

> Taking a quick look into a room to gain better context is a frequent need of engineers and managers reading technical documentation. With 3DIMS this is matter of only seconds. Typing the room number into search box in Resources gets you immediately to your desired destination.

2.3. Virtual Visits and Training

Once understanding the methods of navigation in 3DIMS, the user can enjoy the most basic functionality of the system – to go for a virtual visit or to take someone for a virtual visit in either from a meeting room or also from online Teams meeting.

Although browsing through the plant aimlessly seems waste of time, this method is much more time-effective when for example a person without access to the Controlled Zone wants to get a general idea of how the plant actually looks like.

3DIMS supports an exportation into devices with Virtual Reality (VR) capabilities. JRC, with support of NUVIA Process, have already plentiful experience organising VR visits using sets of VR goggles. These visits are equivalent or even better than the visits in person because out VR environment supports group visits and people can see each other and talk to each other inside the plant. Our VR world is called NDhUb and it might be a topic for another KP.

A more work-oriented application of 3DIMS is its potential to be used for training purposes. Currently, the Specific radiological risks training includes an in-person "visit to the rooms which should not be visited" – a radiation protection specialist takes trainees for a plant walkdown and shows them from outside the rooms where the radiological risks are high. 3DIMS offers a more effective replacement or at least addition to these walkdowns as the risky rooms can also be visited inside. One of the risky rooms in INE plant is the above mentioned bunker 1106 which is contaminated from times of operation. There were 25 scans taken inside this room and it is possible to pinpoint exact areas of high dose or loose contamination (Figure 20).

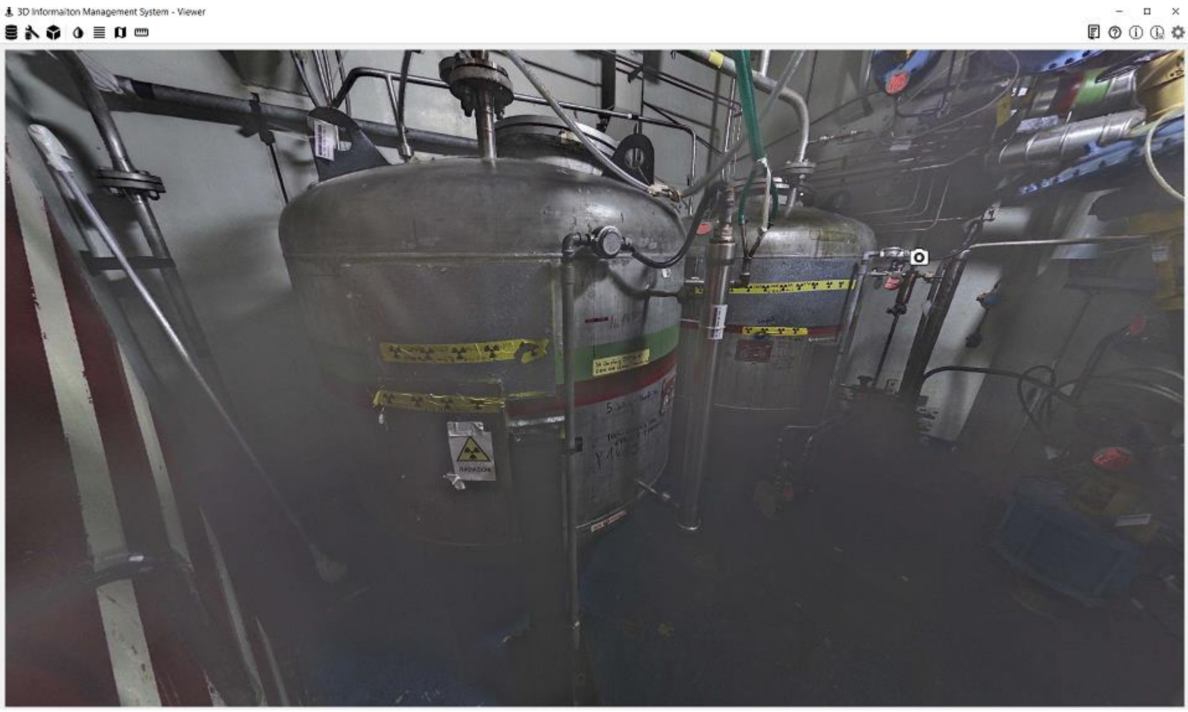


Figure 20: View of tanks in bunker 1106 in 3DIMS

> 3DIMS offers a dose-free and risk-free alternative or complement to the periodical Specific radiological risks training.

2.3.1. Ghosts

A feature noticeable to the user browsing the scanned images in 3DIMS is occasional presence of objects or more frequently persons in movement. This typically results in appearance of incomplete objects or persons in the photos, i.e. "ghosts" – see example in Figure 21.

However, as the high-resolution photo is taken subsequently after the laser scan has been performed (they are made at different times in the same scanning position) and point cloud post-processing has an ability to remove moving objects, the ghosts are not present in the colourised depth image – see example in Figure 21.

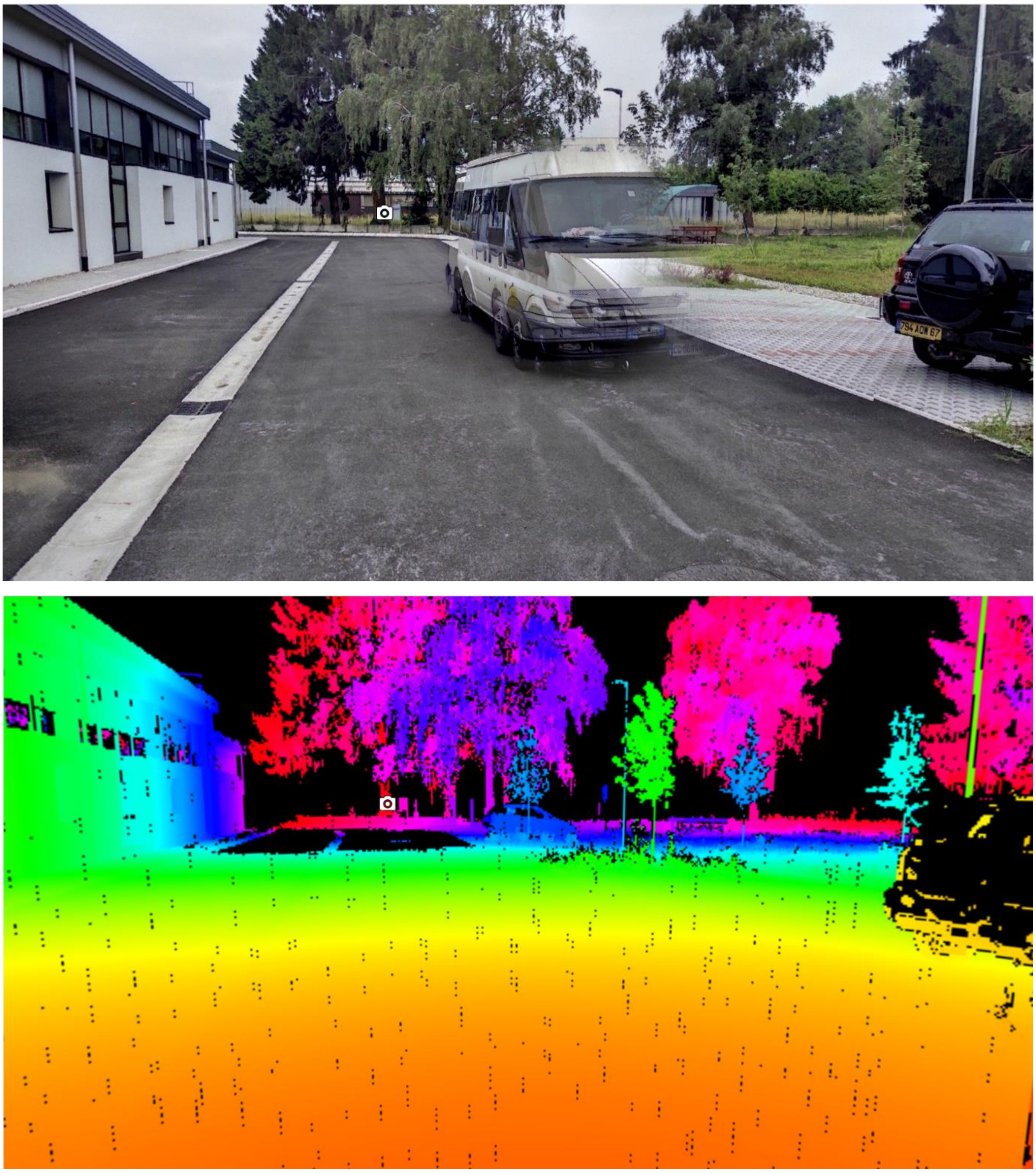


Figure 21: A "ghost" van present in a photo (above) but not in the depth image (below)

2.4. Planning and Engineering

2.4.1. Dimensions Measurements

The 3DIMS Viewer has a built in measurement tool which can be used to virtually acquire precise measurements between any two points using the accurate 3D data at the back-end. This functionality proved to be a very good quick solution for obtaining physical information on components, especially in the Controlled Zone.

Let's take for example that highly radioactive tank visible in Figure 20. The physical properties which must be established during the plant characterisation campaign are its height, diameter, material composition and weight. Any experienced engineer can see from the photo in Figure 20 that the tank is made of stainless steel. Now, how to obtain its diameter. First, the measurement tool must be switched on – see Figure 22.

Then, two measurement points must be selected on opposite sides of the tank in the same height. The welding seam is a good feature to anchor the same height. Then a point is selected on the edge visible in Figure 20 (Scan 18). This must be done by left-clicking on the desired point and selecting "Add measurement" – see Figure 22.

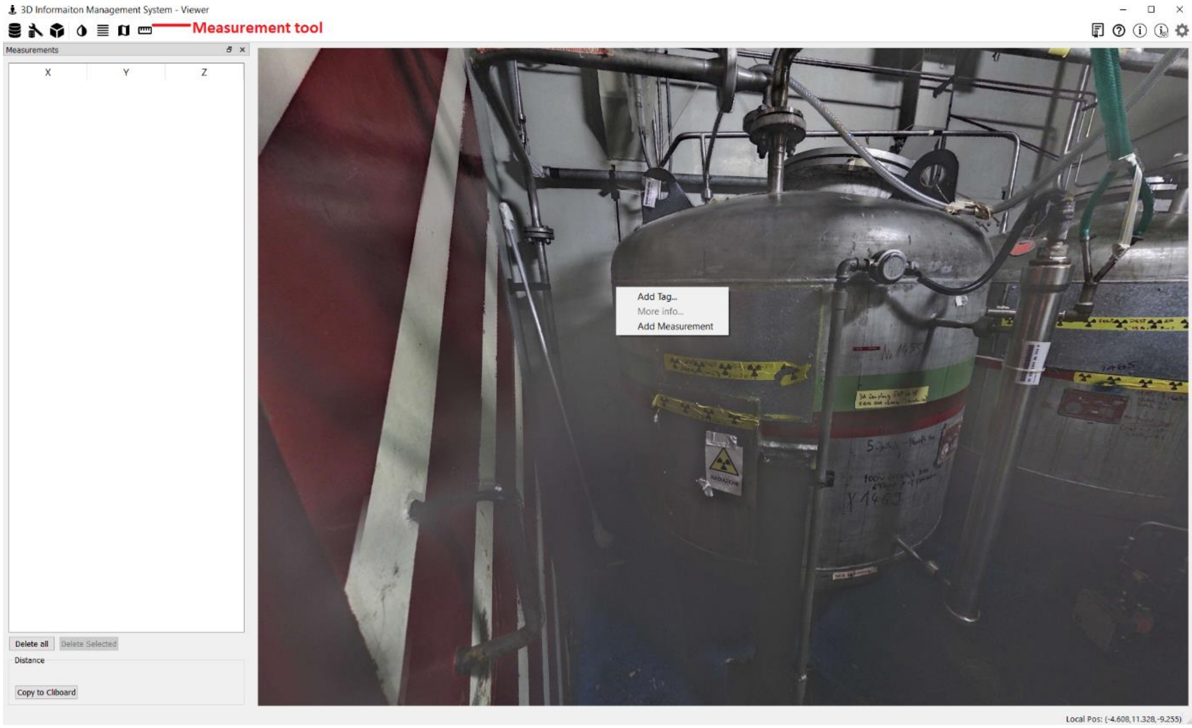


Figure 22: Selecting the measurement point in Measurement tool in 3DIMS

Once selected, the measurement point shows as a black cross in the photo and its (X,Y,Z) coordinates are shown in the Measurement pane.

For correct tank diameter measurement, one has to now select a point on the opposite side of the tank. An important knowledge gained from user experience and definitely not described in the User Manual is that the second point for measurement does not have to be selected on the same scan. For the best vantage position from which a point on the opposite side of the tank could be selected is to look at the 2D map. In our example, Scan 20 is selected and then the second point is added.

When both measurement points are selected in the measurement pane, a straight blue line appears between them on the 2D map. This is a key indicator whether the measurement is done as intended. If the result is not optimum, one of the points (or actually both of them) can be deleted and re-selected. The resulting selection of the two points measuring the tank diameter are shown in Figure 23 and 23.

> In order to carry out distance measurement in 3DIMS, the two points do not have to be selected on the same scan.

Figure 23: Selecting the measurement point in Measurement tool in 3DIMS

Figure 24: Selecting the measurement point in Measurement tool

Check the plan view projection between two measurement points which 3DIMS shows as a blue line on the 2D map.

Once the selection of points is confirmed as correct by the user, the actual distance between two measurement points can be read at the bottom of the Measurement pane. To see it, the user has to switch off the 2D map view – see Figure 25.

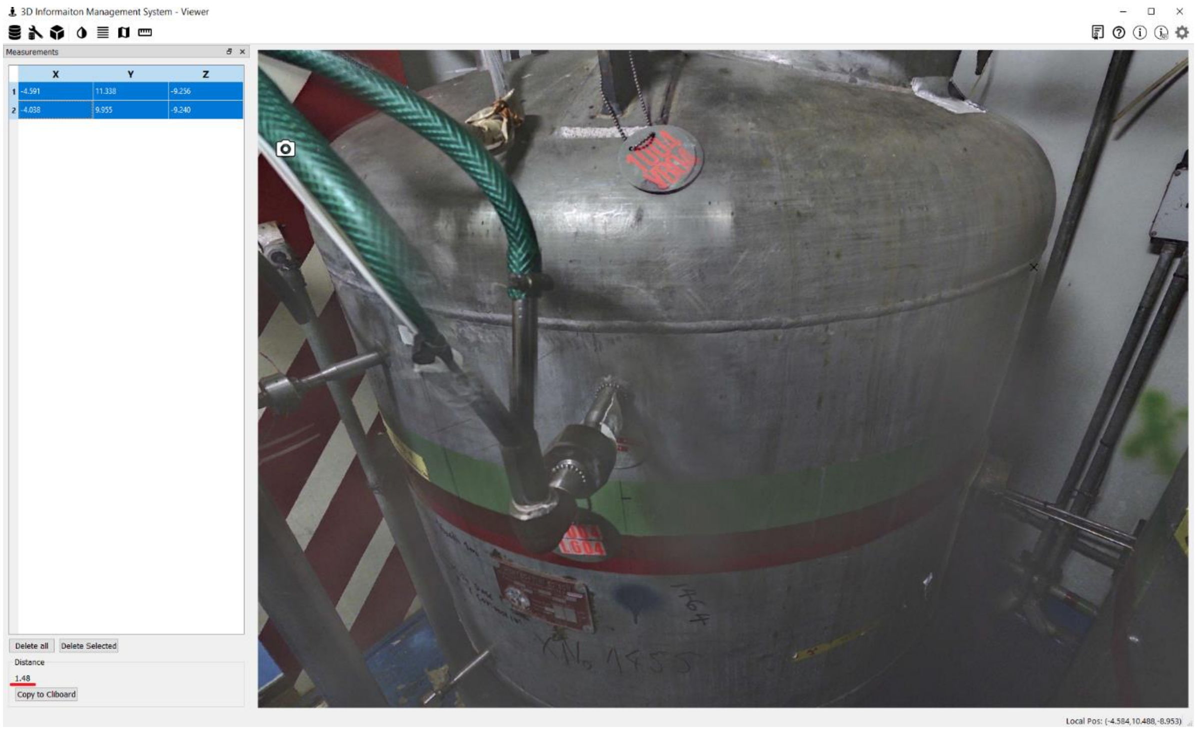


Figure 25: Result of the tank diameter measurement: 1.48 m visible in the bottom of the Measurement pane (where a red line was added to the screenshot)

From the result of the measurement 1.48 m, one can infer that the tank diameter is 1.5 m taking into account that the blue line in Figure 23 and Figure 24 is not exactly matching the line crossing the tank central axis.

Another useful trick for measurement taking is to infer the height values directly from the Z axis values. For example Figure 26 shows a measurement point selected on top of the tank as close to the central axis as possible and the second point on the floor in quite a lateral distance from the central axis. Consequently, the height of the tank including its feet can be inferred from the difference of the Z axis only: -8.93 - (-10.93) = 2 m.

> For measurement of a point height from the floor you can horizontally offset the point on the floor and then only manually calculate the difference of values in the Z axis.

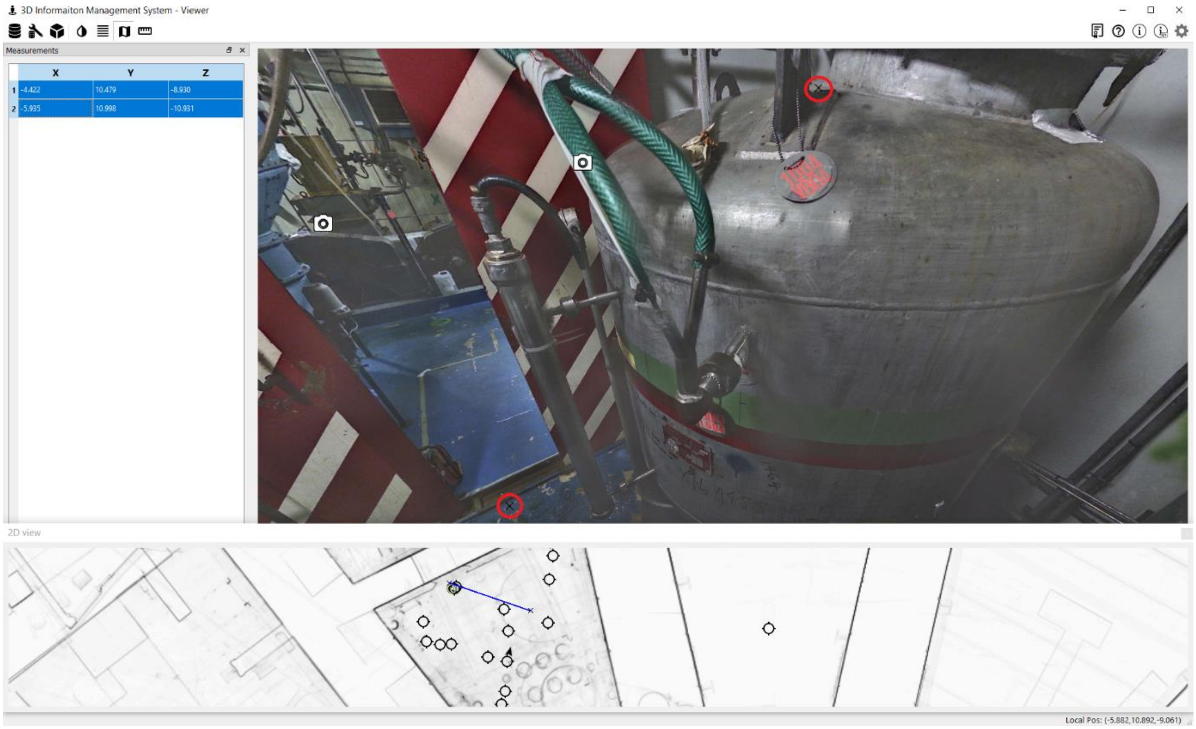


Figure 26: Tank height measurement: Although the two measurement points (red-circled in the screenshot) are not in a vertical line, the height difference can be calculated from the Z axis values visible in the Measurement pane (source 3DIMS software)

Carrying out measurements in 3DIMS is easy, but the user must always check the projection of the measured distance on 2D map to verify that the measured points are as intended. Relying only on the photographic view in the main window can be deceptive.

2.4.2. Continuity of Pipes

Another encountered practical situation when 3DIMS use came very handy was once again continued efforts for improvement of the physical plant characterisation campaign in ADECO. Assignment of the pipes to correct systems is extremely important for not inadvertently mixing two different nuclide vectors. It may happen that a pipe in a room which needs to be assigned to a system does not bear any tag or any colour-coding stripes and it is not connected to any identifiable pipe. Thus, it must be traced through a wall penetration into another room until its system identification is discovered.

A real-life example is shown on Figure 27 and 27. A pipe in ADECO pool rooms 4301 and 4431 which bears no colour coding had to be traced to the adjacent room. Instead of taking a trip to the room 4413, 3DIMS Viewer was consulted and the pipe was easily found and correct system identified – see Figure 27 and 27.

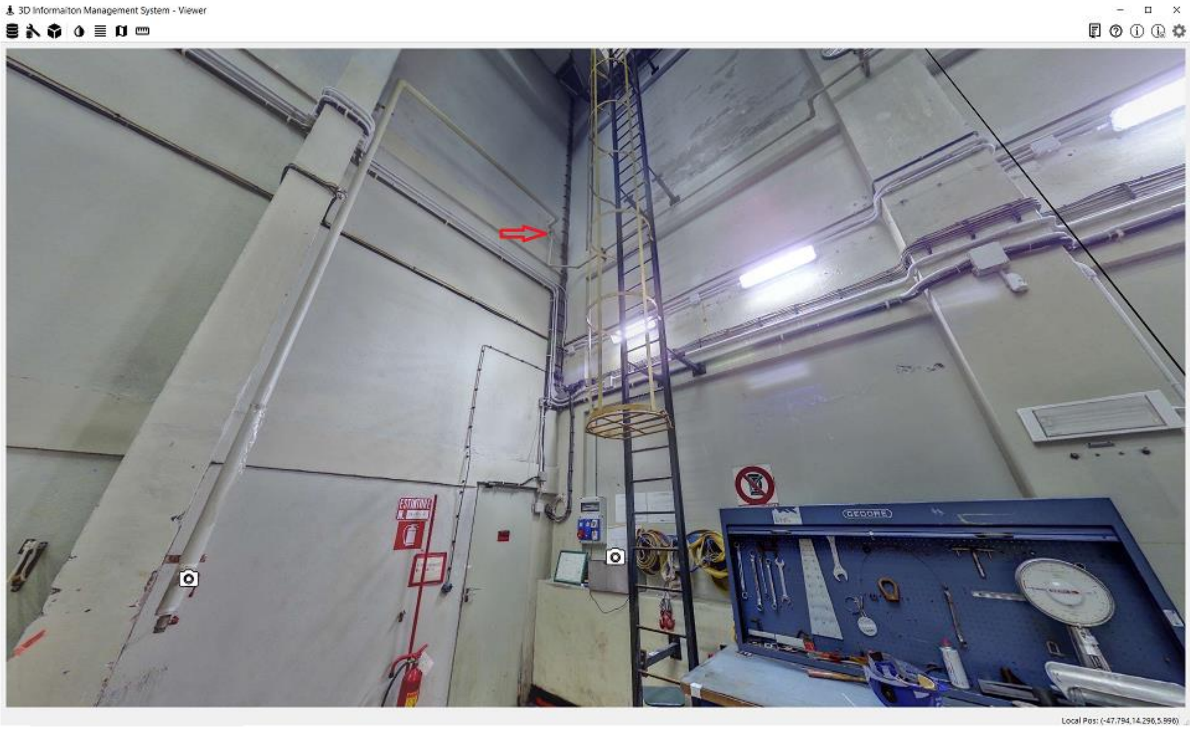


Figure 27: A pipe without system colour coding in room 4301 of ADECO pool viewed in 3DIMS continuing into another room through penetration marked with a red arrow

Figure 28: Continuation of the same pipe in room 4413 of ADECO, here the system is identifiable by colour coding the penetration is again marked with a red arrow

3. PLANNED FUTURE APPLICATIONS AND USES

3.1. Tags

3DIMS is already very useful versatile tool which finds uses for public relations (in form of virtual visits), training and engineering work. The vision for future is that it will integrate with other databases and platforms, MIRADIS database, WITS database, Radiation protection Events Registry (RER), Archive etc. Some features required for such integration are already existent for testing purposes.

All of this can be achieved by means of tags emplaced in the plant. For example components registered in MIRADIS database will have a tag containing MIRADIS code placed on them. In beta version, the components tagging has already been implemented in Cyclotron, but Cyclotron components have not yet been uploaded into MIRADIS database and currently, there is no live link inside these tags – see Figure 29 and 29.

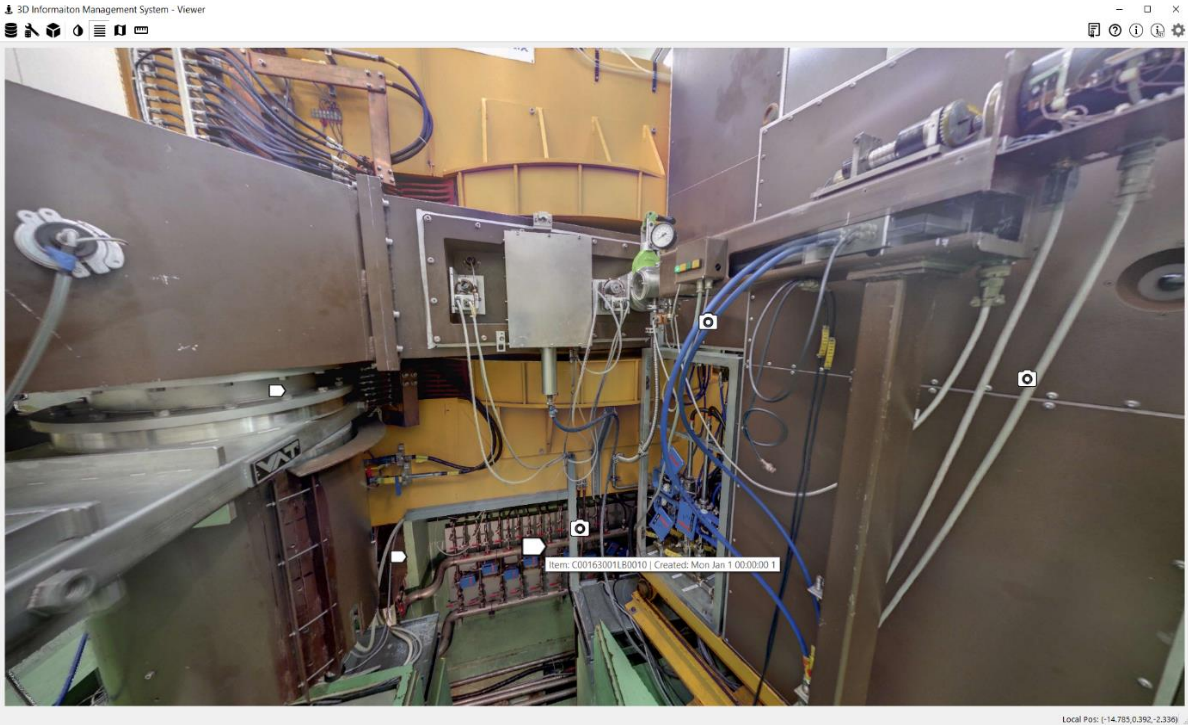


Figure 29: 3DIMS view of Cyclotron where component tags are visible: pointed heptagons; hovering a mouse above the tag shows its name – in this case C00163001LB0010

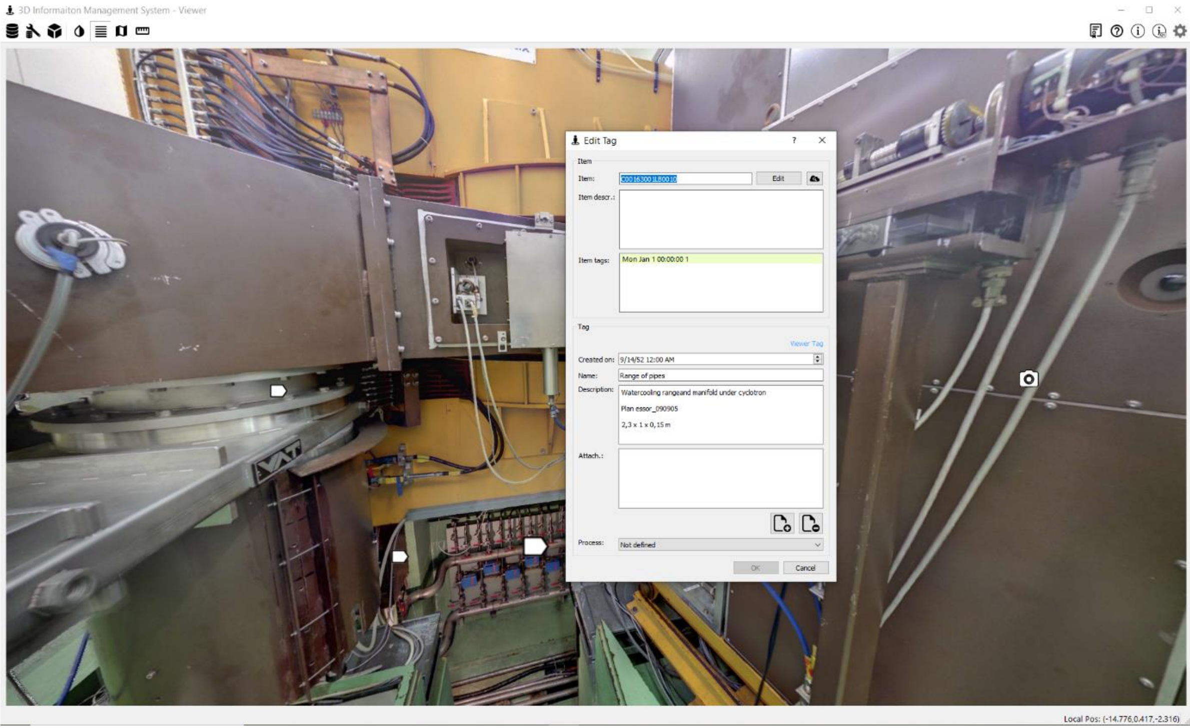


Figure 30: Double-clicking a tag opens an editable dialogue with more detailed information

Obviously, the plan is to connect (read-only) the component tags with live information in MIRADIS database and be able to retrieve immediately all relevant component data.

In a similar fashion, the tags do not have to contain only components' MIRADIS codes, they may also be linked to the drawings or other relevant documents in the NDWMD Archive. For drums, containers and other waste objects generated in dismantling, the tags can be associated with items in WITS database. Radiation protection measurement results can be also tagged and linked to the RER RP registry. Plant characterisation campaign measurement results can be tagged and linked to MIRADIS as well.

In fact, tags are the features which enable embedding any information including any notes. For example, antenna positions during geolocalisation measurements at STRRL were tagged into 3DIMS.

There is one more thing to be said about tags. They can be colour-coded and filtered by colour – see Figure 31. List of all tags can be found in the Resources pane, tab Tags. It is also possible to search for example for a particular component in 3DIMS through a tags search box which appears when clicking on the double arrow next to the Filter tags box – see Figure 32.

It is already possible to enter any tags into 3DIMS today. They may include reference codes of the components, reference codes of waste drums and containers, instruments identifiers, Archive document codes, references to measurement reports or even personal notes (visible to every user).

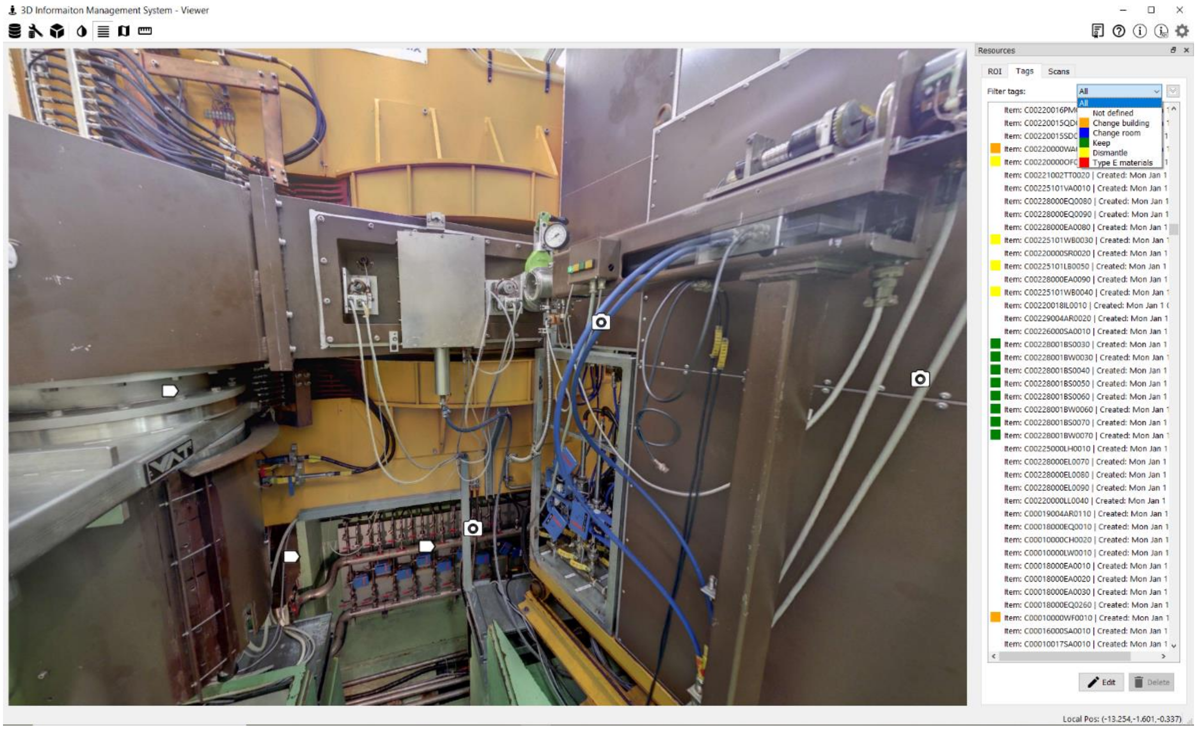


Figure 31: Filtering of tags

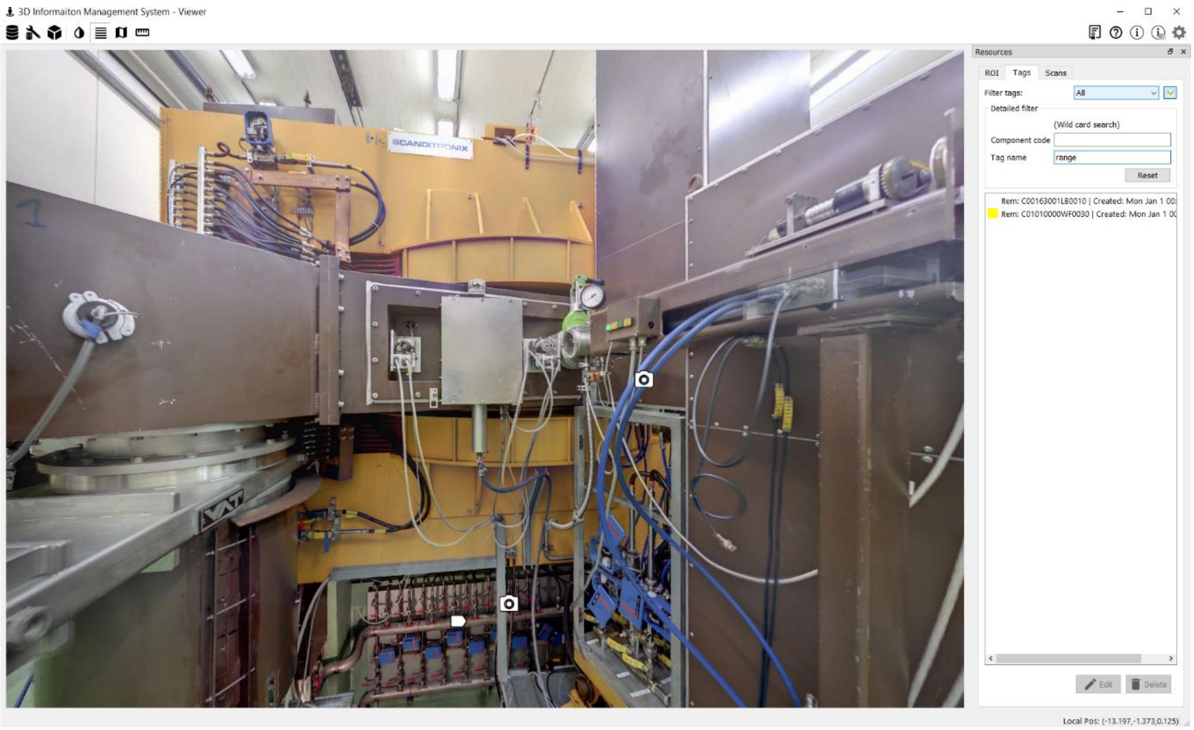


Figure 32: Searching in tags – only filtered tags remain visible

When all visible components will be tagged, their location will be an easy task by means of searching for the MIRADIS code in tags search field.

Similarly, location of instruments or waste objects can be found by means of tags search.

3.2. Components Shapes

One of the features being discussed as proposal for future improvement of 3DIMS is addition of simple shapes representing the components, for example lines for cables, cylinders for pipes, balls for valves, blocks (parallelepipeds) for cabinets etc.

This feature could become a major step forward for the interoperation and synergy between 3DIMS and MIRADIS. As already mentioned earlier, in a nuclear plant, often two rooms are not segregated by a wall and sometimes it is difficult to distinguish where one component (for example a pipe) ends and another starts (see Figure 1).

There is no geolocalisation information and neither any photo for any of the components in MIRADIS database and therefore tagging and representing a component using a simple shape will supplement this knowledge and will lead to much easier decommissioning planning.

3.3. Radiological Properties Visualisation

Another feature foreseen for future is visualisation of dose fields or contamination hot spots on the screen. This feature is already implemented as two different overlays on the photos. The first type is an image taken using a gamma camera which has been transposed onto the 3D model within 3DIMS. Currently, it is available only in a single scan ADECO_A_209 (at the beginning of the scanning campaign unsuitable file names were used – see also 2.2.4).

Currently this gamma image cannot be switched off, it is permanently overlaid onto the scan. In future, with more gamma images available, this will be a feature which can be switched on and off.

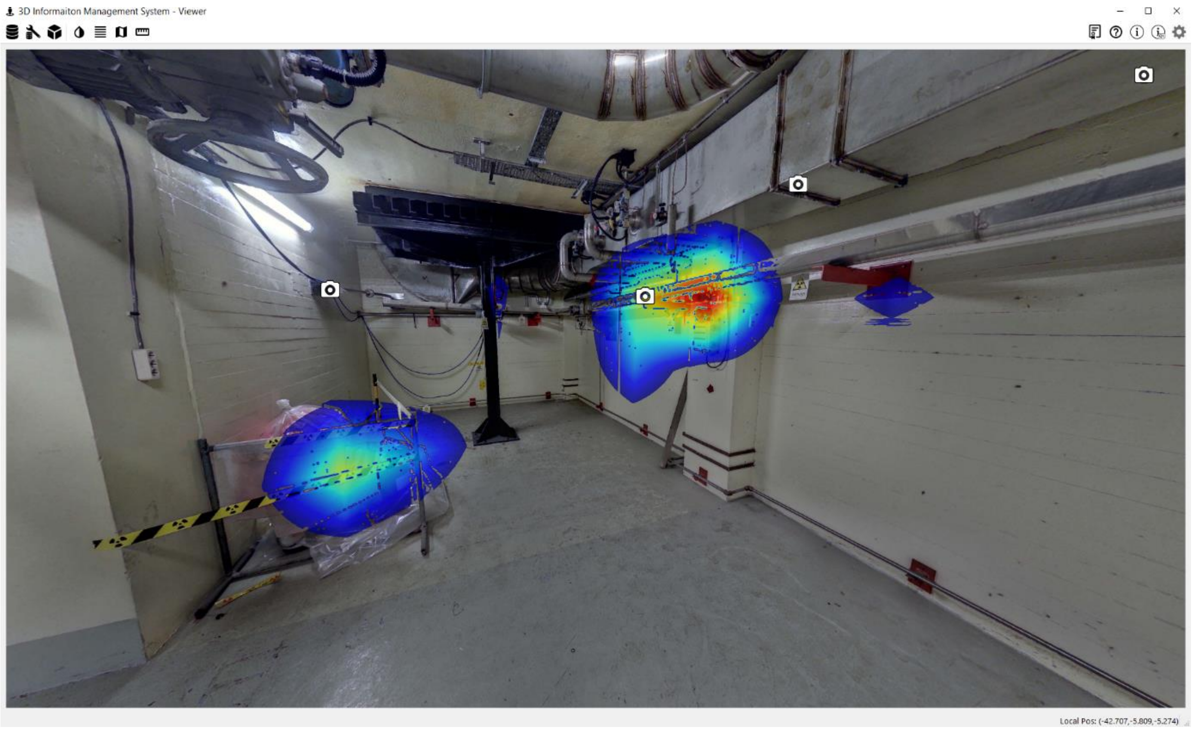


Figure 33: Overlay of a dose image from gamma camera onto the scan ADECO_A_209

👍	3DIMS offers a significant added value of trainings and visits by making visible dose and contamination information for each room with high radiological risks.

A second method of visualising radiological information is implemented in building 52A. In this case, dose measurements were carried out using a trolley equipped with a radiological instrument pointed onto the floor.

Figure 34: Mobile Laser Scanning Platform coupled with a gamma detector (NaI radiological identifier detector)

In this case the result is presented as an overlay on the 2D map. Activation of this feature is a bit more complicated. First, a ROI “Ed 52A” must be selected in “Area 52” database. At this point, a new button for toggling additional layers appears in the menu bar – see Figure 35. Clicking on it, a dialogue appears from which Gamma Mapping should be selected – see Figure 36.

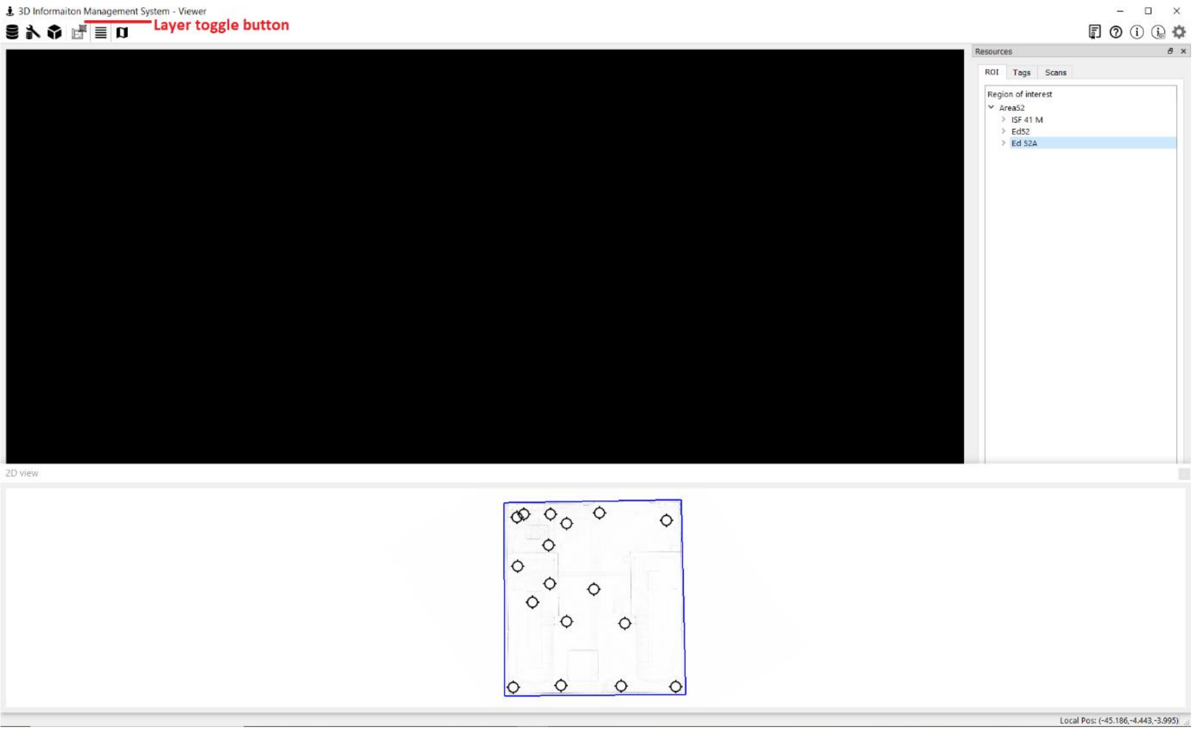


Figure 35: How to activate an overlay layer for gamma contamination (dose) in building 52A step 1

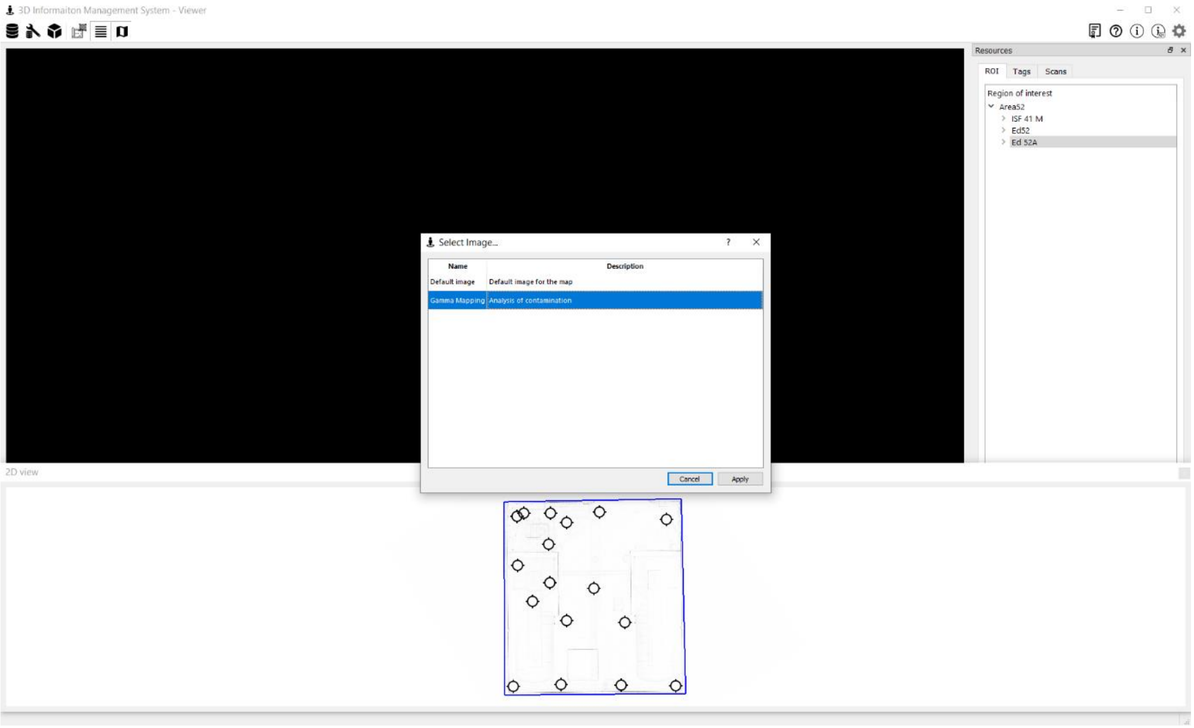


Figure 36: How to activate an overlay layer for gamma contamination (dose) in building 52A step 2

Immediately, even without selecting a scanning position, an overlay of gamma contamination map appears on the 2D map – see Figure 37.

Figure 37: Overlay layer for gamma contamination (dose) in building 52A in 3DIMS

The legend for this map can now be made available in the Resources pane by clicking on the Layer info: Gamma Mapping at the bottom of the Resources pane.

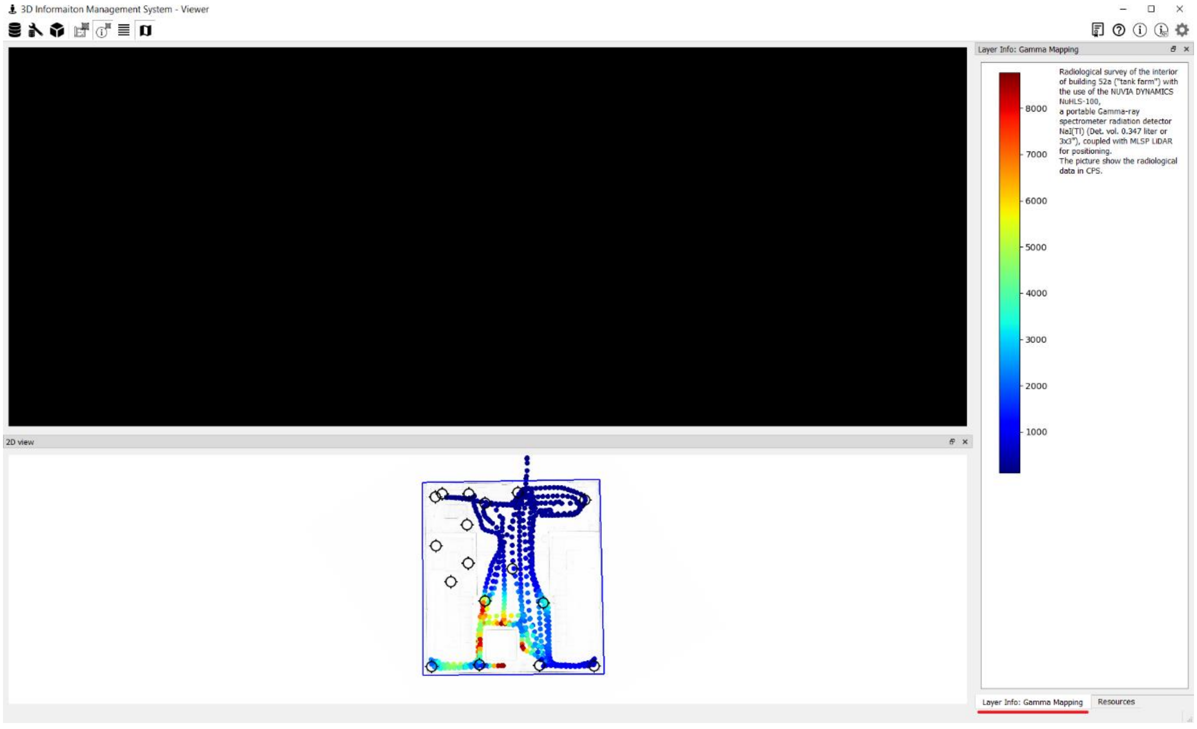


Figure 38: Legend for gamma contamination (count per seconds) appears by clicking on the Layer info: Gamma Mapping – red underline was added onto the screenshot

These feature will become important for future trainings on specific radiological risks when additional gamma images will be taken in the risky areas.

Other important applications with embedded radiological data in 3DIMS are also foreseen through connection of dose and contamination monitors installed around the plant in dynamic (live) mode:

- Area monitoring can become presentable in a 3D model
- Monitoring instruments alarms will be immediately geolocalised
- Nuclear emergency management will get a new powerful tool for spatial contamination spreading monitoring

3.4. Change Detection (Visualisation of Plant Configuration Change in Time)

Another feature already implemented in 3DIMS is a capability to detect change between two scans performed in the same position but in different times. Thus the progress of dismantling can be easily tracked and visualised. This is above all a powerful managerial tool but it will also enable additional level of all-important traceability in our project.

Currently the change detection is only possible in Cyclotron where full scanning campaign was carried out before donation and five scans were added after the donation of the equipment for reuse in Czech Republic. In order to view it, one must open Cyclotron database and then type “2022” into search box of the Scans tab in Resources pane (Figure 39). This will filter out five scans taken in year 2022. Once any of them is opened by double-clicking, one can notice that a new icon for toggling the scan image layer appears in the menu bar. By clicking on it, a dialogue appears in which Change detection 2019 -> 2022 must be selected – Figure 40. As a result, dismantled components (which are missing in current view compared to the past) appear as red silhouettes while any added objects gain a green silhouette – Figure 41.

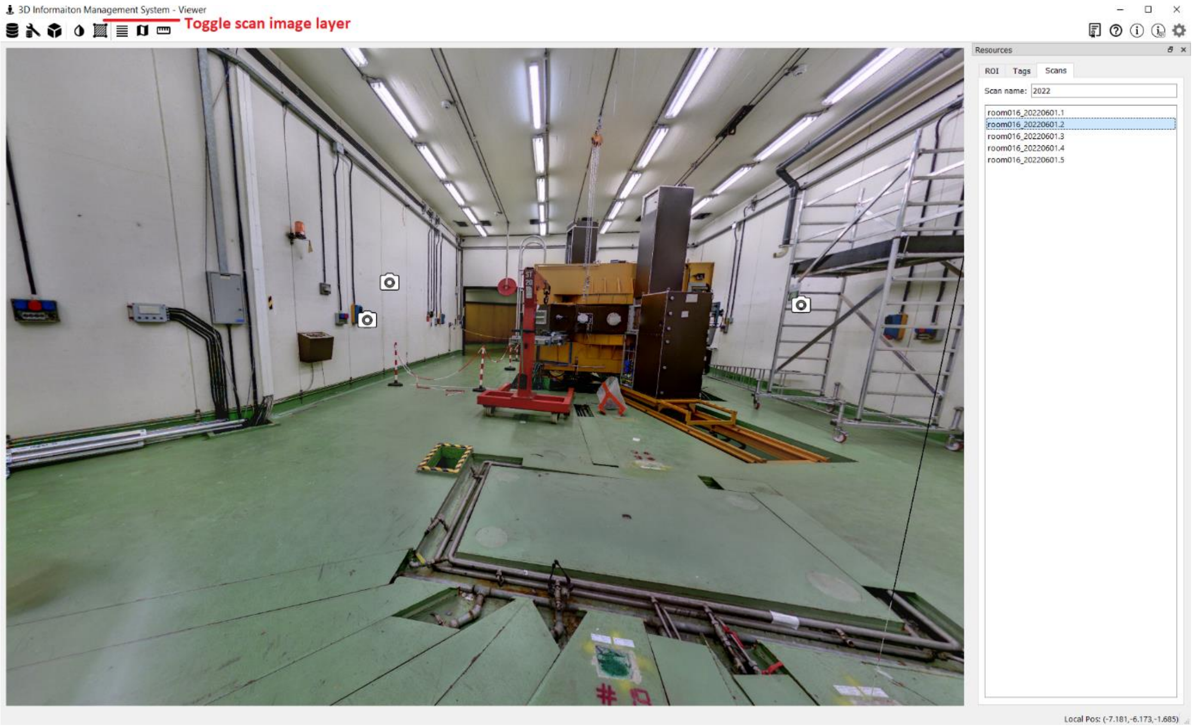


Figure 39: Change detection toggle button available in 3DIMS for five scans of Cyclotron taken in 2022

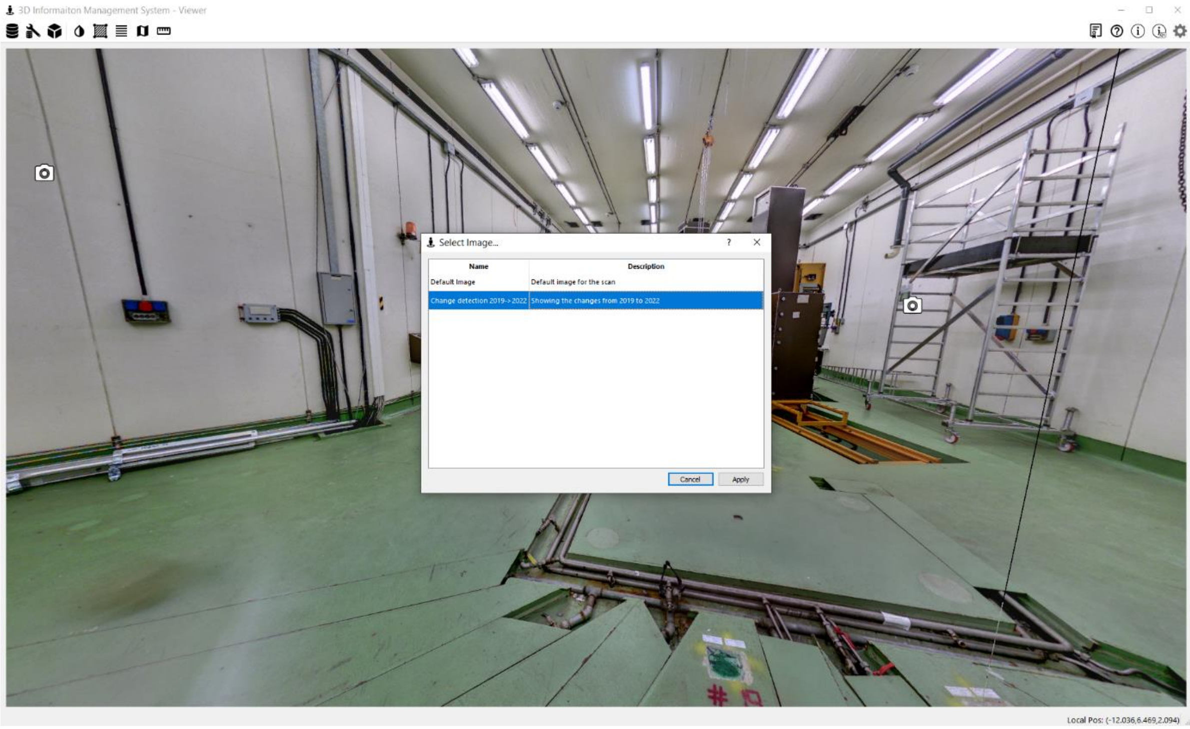


Figure 40: Change detection dialogue in 3DIMS

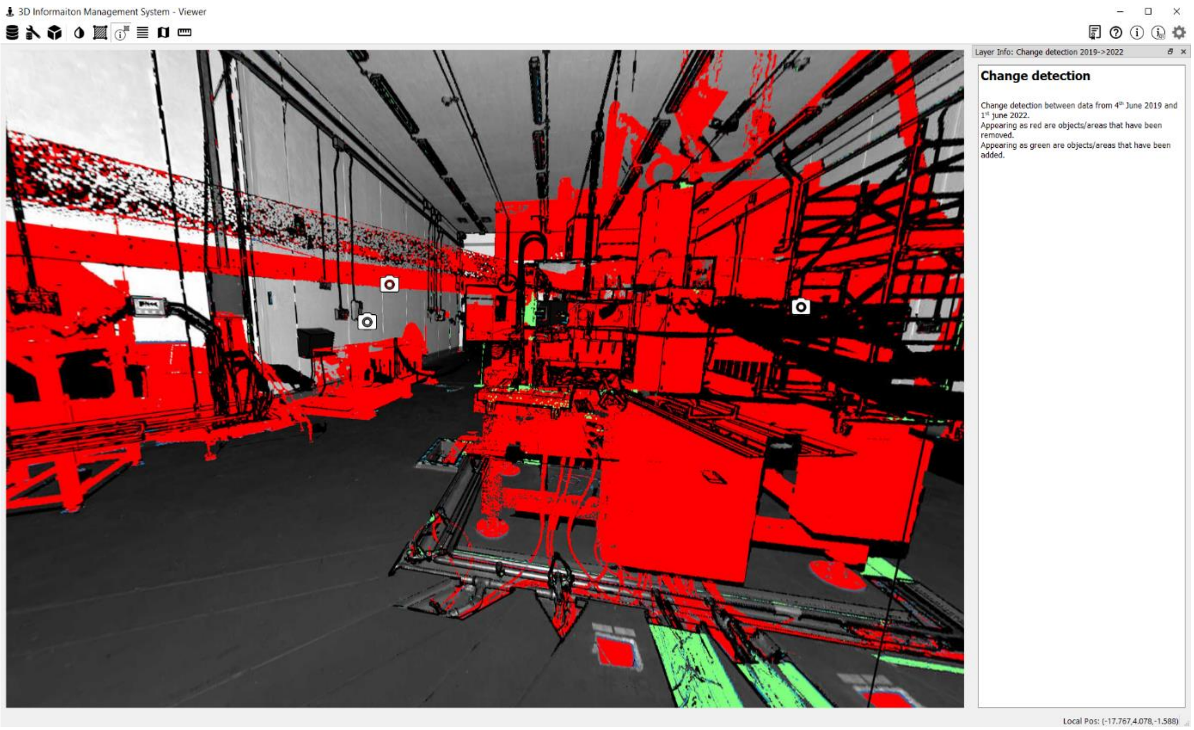


Figure 41: Change detection visualisation in 3DIMS

3.5. Augmented Reality

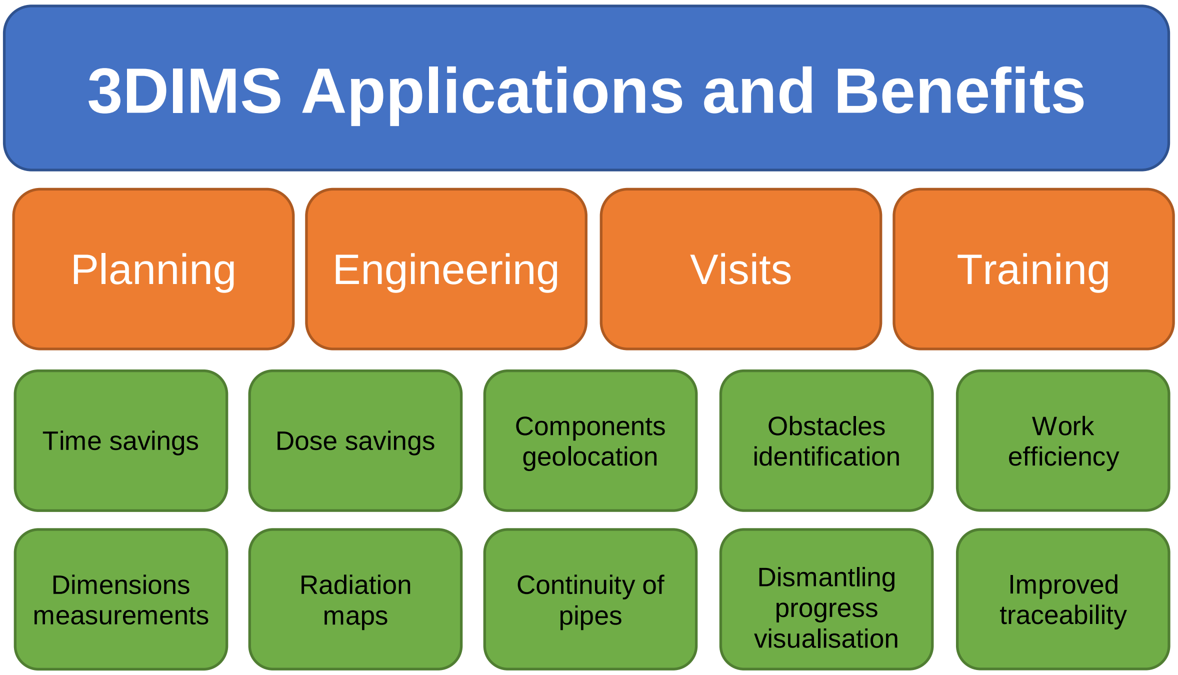
A major change in mode of utilisation of 3DIMS will be its spin-off into Augmented Reality (AR). The spatial information from 3DIMS will be imported into AR devices which when taken into the field, will be able to “recognize” the environment, apply the components tags, WITS objects tags, retrieve live information from MIRADIS and WITS, drawings from Archive, dose visualisation and detect change of the status in the room.

All of this will give users much more advanced digital support for all the decommissioning activities and the system will start to resemble to the most modern BIM systems being used in the construction industry.

> 3DIMS will be the basis for AR applications that will enable to walk through the plant with AR headset and view information about components, waste objects, radiological situation or progress on dismantling works overlaid on the real environment.

4. CONCLUSIONS

3DIMS is relatively young product which still does not have wide users base in NDWMD of JRC. Nevertheless, 3DIMS is already very powerful tool which can substantially increase effectiveness of the engineering work in the Unit. Hopefully this knowledge product helps to gain new users by showing variety of its uses, applications and benefits.



5. REFERENCES

[1] «Nuver3DIMS_UserManual.pdf» available on request from gunnar.bostrom@ec.europa.eu