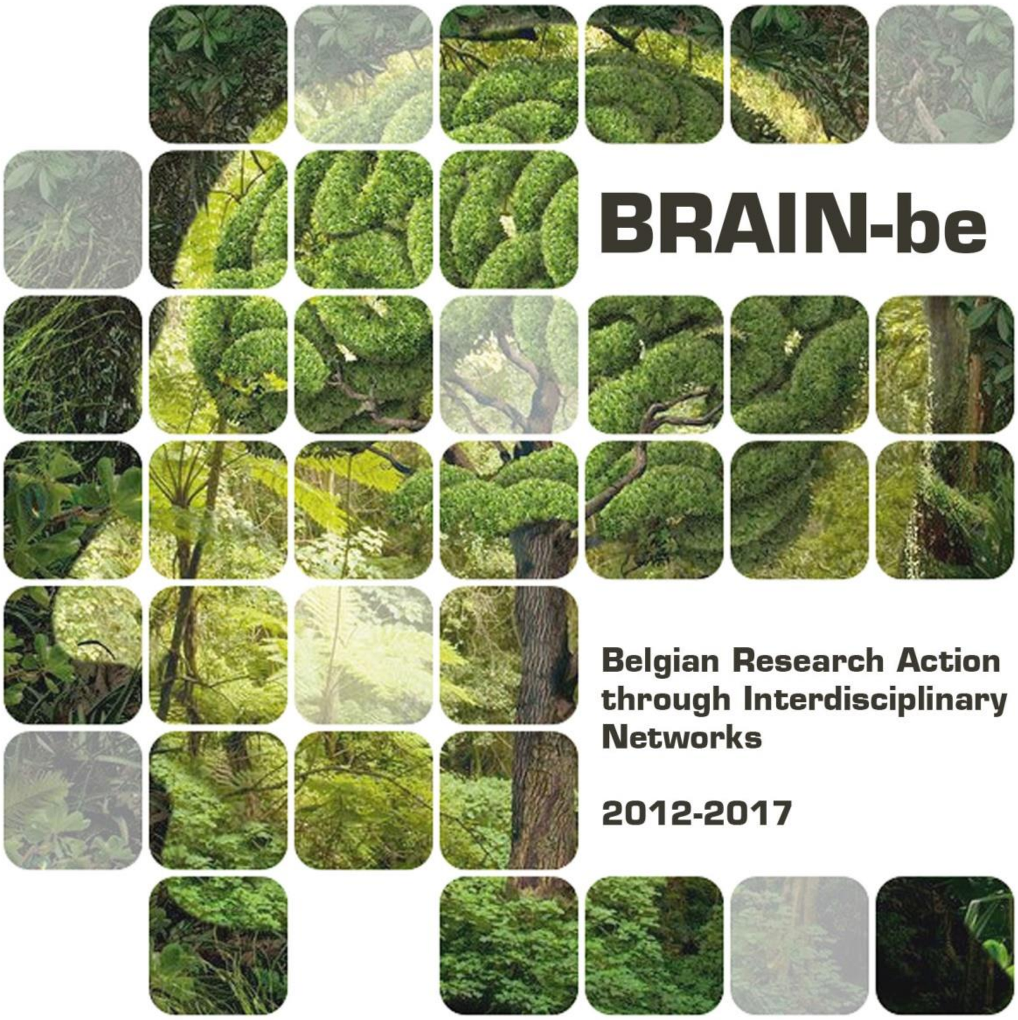

ARTGARDEN

Art Technical Research and Preservation of Historical Mixed-Media Ensembles: 'Enclosed Gardens'

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Axis 6: Management of collections

BRAIN-be

Belgian Research Action through Interdisciplinary Networks

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NETWORK PROJECT

ARTGARDEN

Art Technical Research and Preservation of Historical Mixed-Media Ensembles: ‘Enclosed Gardens’

Contract - BR/154/A6/ARTGARDEN

FINAL REPORT

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ABSTRACT

Central to the ARTGARDEN project is the unique collection of seven 16th century Enclosed Gardens from the Mechelen City Museum. These *Horti Conclusi* are wooden retable cabinets with virtually countless little elements (about 400 per cabinet) composed of a multitude of materials in complex configurations: brass and silk flowers, glass and brass berries, polychrome wooden statuettes, paper banderoles, relics, wax etc. The restoration of these extraordinary Belgian heritage artifacts was the starting point for this network project. The ARTGARDEN team comprises art historians, conservator-restorers, preventive conservation specialists, imaging specialists and conservation scientists, who delve into the multifaceted process of researching and safeguarding each Garden, as well as other types of historical mixed-media objects. One part of the project focuses on conservation treatments, supported by advanced imaging techniques, laboratory analyses and art historical research. Another part tackles preventive conservation issues. For complex objects like the Gardens, the choice of preventive conservation measures is not straightforward. Therefore a user-friendly and free online decision-support tool - AGATO - has been developed to help heritage caretakers make more knowledgeable preservation decisions https://agato.kikirpa.be/ . AGATO assists the user with an overview of risks that could cause damage to his/her object, with recommendations for the preventive conservation of the materials most susceptible for damage. These should enable him/her to decide which action to take. The AGATO website is also the flagship of the overall ARTGARDEN project.

Keywords

Enclosed Gardens of Mechelen - Advanced imaging techniques - Historical mixed-media artefacts - Mixed material interactions - Preventive conservation - Collection management - Online decision support tool AGATO – Object risk warnings & recommendations - Iconography & technical art history - Physico-chemical analyzes

1. INTRODUCTION

The seven 16th-century Enclosed Gardens of the Hospital Sisters of Mechelen, listed as masterpieces by the Flemish 'Topstukken' Decree, are very rare in Belgian and even world heritage. Most other Enclosed Gardens or *Horti Conclusi* have been lost, mainly due to a lack of interest. This changed a few years ago: these 'popular retables' are now considered as testimonies of a 16th-century (women's) spirituality that by their unique pictorial vernacular give an idea of life in convent communities. They testify to a cultural identity closely connected to mystical traditions. They are a gateway to a lost world, an essential part of culture in the Southern Netherlands. (https://vimeo.com/118596740)

Fig. 1: Seven Enclosed Gardens of Mechelen with size scaling

Previously, objects such as the Gardens did not receive any art historical or conservation attention due to their nature, the complexity of their components and the apparent triviality of the various materials that make up such objects (glass beads, silk vegetation, paper, wax, bone, stone, seeds, metal wire, etc.). The time was ripe to finally take a closer look at such pieces as well as similar and other historical mixed-media objects.

Many of the constituent materials of such objects, either alone or in combination with other materials, in an enclosure or not, are vulnerable to natural ageing through breaking, corroding, fading, etc. Up until now, guidelines for restoration, conservation & preventive conservation have concentrated mainly on individual material characteristics. But conserving historic mixed-media artefacts is less developed and more challenging due to their complex nature and interaction problems. Museum collections however contain large numbers of mixed-media objects, both in Belgian (federal) institutions as in collections worldwide. The conservation and preventive conservation issues related to the complexity of mixed material interactions is a universal problem and a headache for every collection manager and object restorer.

At the time of writing the ARTGARDEN proposal, a team of 8 conservator-restorers - each specialized in the restoration of a specific material - was working on the conservation and restoration of Mechelen's seven Enclosed Gardens in the restoration workshop of the Museum Court of Busleyden of Mechelen (2014-2019). This extended team well illustrates the complexity and the high need to explore these rare historical ensembles of mixed-media in-depth. Though, the ongoing hands-on treatment did not include extensive research activities, which could improve the restoration treatment and the general knowledge on historical mixed-media objects. The ARTGARDEN project originated here.

Thus, the first and main ARTGARDEN casus is the preservation of this unique collection of Enclosed Gardens (Fig. 1). The (sometimes partial) physical dismantling of the Gardens opened up great potential for research in order to find answers to universal questions within the world of collection management and the conservation and restoration of similar mixed media objects. Therefore, following questions needed to be answered:

- What is the art historical & anthropological pedigree of the Enclosed Gardens?

- What is their related material-technical pedigree (and their conservation history)?

- Which materials and techniques do the Enclosed Gardens consist of and how (and by whom) are they made?

- What is the overall conservation state of the Gardens and the condition of the materials (degradation phenomena)?

- What is the link between the (art) historical & anthropological pedigree of the Enclosed Gardens and their material-technical pedigree, conservation history and the degradation phenomena?

- How should such objects be treated/restored?

- How can we best document this treatment?

- How and why do the materials in the Gardens interact (or not) with each other?

- Which are the overall risks for the conservation and preservation of the Gardens?

- In what circumstances should they be conserved in order to delay further decay?

An attempt was made to answer these research questions using various invasive and non-invasive research techniques to study a corpus of 13 historical mixed-media objects, among which the seven Gardens. The main corpus of the project were the seven Gardens. These were investigated, restored and are exhibited in the best possible way in the new Museum Court of Busleyden in Mechelen. The other 6 additional objects came among others from Federal Scientific Institutions and provided further understanding of material degradation and material interactions (Fig. 2). Most research results on the Gardens were shared extensively at conferences, in an elaborate publication, in scientific articles and exhibition catalogues as well as on the project website AGATO. The AGATO website, showcase of the ARTGARDEN project, is additionally a free and user-friendly online tool and was developed based on the research, to alert collection managers of the risks associated with the preservation of their historical mixed-media objects.

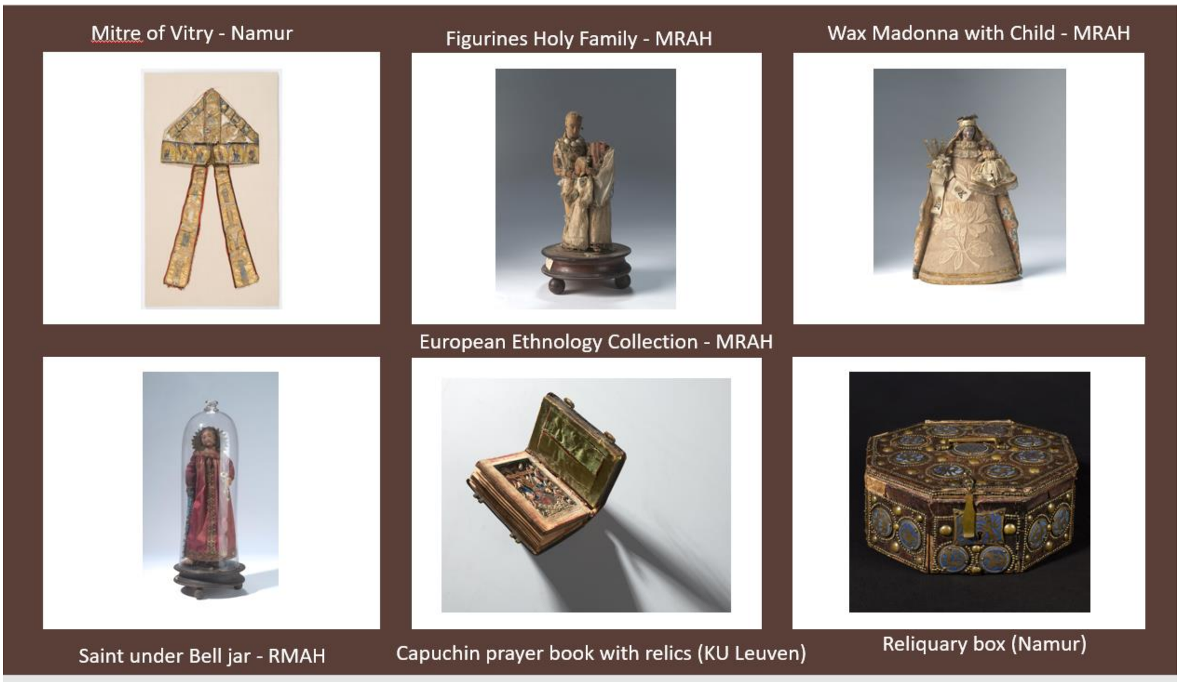


Fig. 2 : Six additional historical mixed-media objects from the ARTGARDEN research corpus

2. STATE OF THE ART AND OBJECTIVES

2.1 State of the art

As said, the conservation issues of historical mixed-media objects such as the Gardens are universal. The material interaction issues of mixed-media objects from all over the world are countless and are not fully researched yet.

The project around the Enclosed Gardens was submitted because of the unique and exceptional status of these - until then undervalued - objects. Their restoration, the ARTGARDEN project and its research results give the Gardens (inter)national fame and ensure their exceptional future preservation and exhibition, this for future generations of visitors and researchers.

The Gardens consist of countless materials also found in other historical mixed media objects worldwide. The research on the many types of materials of the Gardens teaches us more about the Gardens themselves but this knowledge is also invaluable internationally. The research results encompass international potential. The acquired expertise on degrading interactions between materials and how to slow them down fills a gap at the federal, national and international levels.

Examining other mixed media artefacts in addition to the Enclosed Gardens will raise the profile of this type of underappreciated collections. It increases attention and care for the many historical mixed media objects worldwide (folk art, ethnographic art, religious artefacts, costumes, manuscripts...).

The multitude of materials present in mixed-media objects such as the Enclosed Gardens, turns making well-informed preventive conservation measures into a huge challenge. Yet, apart from the existing risk assessment methodologies aimed at collections, there was no online tool available for the assessment of a single mixed-media object. Hence the motivation to develop a user-friendly and free online decision-support tool for heritage caretakers, to enable them to undertake more knowledgeable mitigation actions to improve the preservation of their object.

2.2. Objectives

Objective 1

Investigate the (art) historical & anthropological pedigree of the Enclosed Gardens and their material-technical pedigree, conservation history and the degradation phenomena.

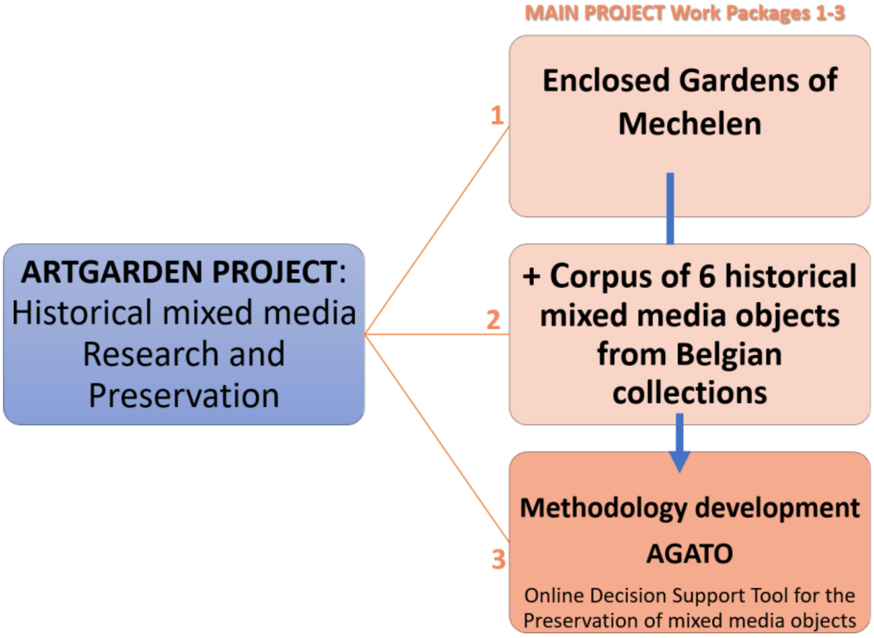
Investigate the overall risks for the conservation and preservation of the Gardens, and how the objects need to be treated/restored (under which circumstances and within which delays) in order to delay further decay.

Objective 2

Develop AGATO, a free and user-friendly online tool that will alert collection managers to the risks associated with the preservation of their historical mixed-media objects, fed by mixed-media knowledge coming from literature research and the new insights gathered from research on the ARTGARDEN corpus, as well as built-up own expertise on risk analysis for cultural heritage.

3. METHODOLOGY

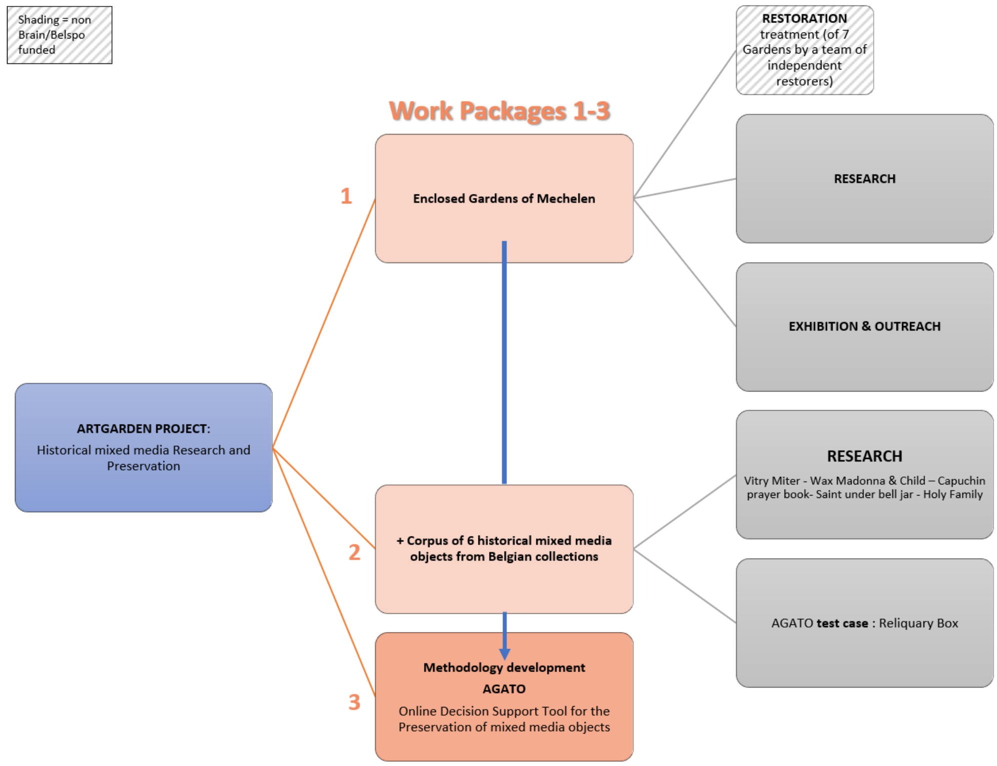
TABLE I : ARTGARDEN methodology with WP 1-3



The methodology of ARTGARDEN had 3 main phases or project work packages:

1. Research on the 7 Enclosed Gardens of Mechelen (during their restoration treatment, which was not funded by Belspo)
2. Research on a corpus of 6 historical mixed media objects from Belgian collections
3. Methodology development resulting in an online decision support tool for the preservation of mixed media objects : AGATO

TABLE II : ARTGARDEN methodology with WP details



3.1 Work Package 1: Enclosed Gardens of Mechelen

3.1.1 Research

The research by the consortium started during the restoration of the Gardens by a team of independent conservator-restorers (non Belspo funded, led by Lieve Watteeuw and Joke Vandermeersch):

- consolidation tests (for treatment)

- restoration protocols

- art historical, art technical & anthropological research

- material-technical research, degradation phenomena & material interactions

- scientific documentation/imaging (X-Ray, IR, UV, vis. light, Microdome)

- preventive conservation research (risk analysis & advise for long term exhibition, storage & transport)

Research by KIK-IRPA : Textile Research Lab & the Lab of Paper, Leather & Parchment

Physico-chemical analysis have been performed on 11 objects to characterize the constituent materials and techniques such as wax, paint, textile fibers, colorants, metal,... This was mainly done in a non-invasive approach. In order to preserve the objects as much as possible, only a limited number of micro-samples was withdrawn to be analysed by complementary analysis techniques.
The degradation of the silk fibers, which was strongly pronounced for the different textile objects of the Enclosed Gardens of Mechelen, was studied in detail with spectroscopic, chromatographic and microscopical techniques.

Research by KU Leuven : Book Heritage Lab & VIEW - KU Leuven Core facility for Heritage Science and Digitization Technologies

The team of KU Leuven extensively studied the Enclosed Gardens of Mechelen during the restoration project (2014-2019). The art historians and conservators of KU Leuven studied in particular the significance of the Gardens' complex content and visual language. Conservator-restorers and technical art historians explored their particular physical features. The knowledge gathered during the restoration was essential for pinpointing focused research objectives such of characterization and combination of different materials in one extremely small artistic artefact. The team of photographers used advances imaging techniques such as multispectral photometric stereo to monitor characteristics and changes during the five year conservation-restoration treatment.

The *Mitre of Jacques de Vitry*, the *Casket for the crown reliquary of Holy Thorns* and the *Capuchin prayer book with relics* were studied by the VIEW in context of their historical, iconographical and material value. The team of KU Leuven investigated the historical materials and techniques in depth, aside of the written art technical sources and iconographical representations of particular elements.

Research by University of Antwerp : A-Sense Lab / Antwerp Electrochemical and Analytical Sciences Lab

The A-Sense team focused on the in-depth analysis of metal and glass objects, with the final aim of unravelling composition, material properties and reactivity of these historical materials. In particular, the team researched the material properties behind the extraordinarily pristine conservation state of a series of brass sequins in the 16th century Enclosed Gardens. The results of this fundamental research allowed to answer key questions about the reactivity of historical alloys in indoor conditions, ultimately highlighting the capital importance of the manufacturing process on the long-term stability of historical brass.
A deeper understanding on the influence of the microenvironment and surroundings on the reactivity of historical brass was also obtained. In particular, thanks to the application of novel analytical methods such as Optical Photothermal IR (O-PTIR) spectroscopy, evidence of glass-induced corrosion processes on historical brass decorative elements was obtained. This key information resulted in a deeper understanding of present and future risks for unique

cultural heritage objects, translating into optimized preventive conservation strategies. In the context of material-material interactions and air quality analysis, the team also conducted volatile organic compounds (VOCs) sampling and analysis in historical showcases and objects.

3.1.2 Exhibition and outreach

- 1 exhibition in Leuven & 2 in Mechelen's Hof van Busleyden

- exhibition catalogues

- PhD thesis

- scientific publications

- lectures & posters at conferences

- research reports and results on the AGATO website

3.2 Work Package 2: Corpus of 6 historical mixed media objects from Belgian collections

- Saint under bell jar : European ethnology collection, Art & History Museum, Brussels
- Figurines Holy Family : European ethnology collection, Art & History Museum, Brussels
- Wax Madonna with Child : European ethnology collection, Art & History Museum, Brussels
- Casket for the crown reliquary of Holy Thorns : Treasury of the cathedral of Saint-Aubain, Musée diocésain de Namur
- Mitre of Jacques de Vitry: Musée provencial des Arts anciens du Namurois, Namur
- Capuchin prayer book with relics : KU Leuven - Maurits Sabbe Library, Leuven

3.2.1 Research

- art historical, art technical & anthropological research

- material-technical research, degradation phenomena & material interactions

- restoration treatment/exhibition/storage (some objects)

- scientific publications, lectures & posters at conferences

- research reports and results on the AGATO website

For details on research on the corpus of the 6 additional objects, cfr. Supra *3.1.1 Research by the partners.*

3.2.2 In-depth case study for ARTGARDEN and AGATO: Casket for the crown reliquary of Holy Thorns

- art historical, art technical & anthropological research

- material-technical research, degradation phenomena & material interactions

- restoration treatment (non Belspo funded)

- Quick Risk Scan & preventive conservation advise for owner

3.3 Work Package 3: Methodology development for AGATO

Collection managers worldwide are responsible for the preservation of complex heritage like the Enclosed Gardens and other mixed media artefacts. Several reasons are at the root of the poor knowledge and condition of such art collections: the inferior status of historical mixed media artefacts in general, their multiplicity and complexity of constituent materials that all react differently and mutually to (museum) environmental factors, the lack of research and knowledge about this type of collections and its problematics, and last but not least, the general lack of sufficient staff and budget for sound collection policy and preventive conservation.

In the field of cultural heritage, decisions concerning the conservation-restoration of unique and valuable artefacts do not happen overnight. In the decision-making process, many factors are taken into account and weighed against each other (Michalski and Rossi-Doria 2011). This is no different when deciding on preventive conservation measures for objects.

It is therefore logical that these complex assessment processes should rely on models and tools that seek to objectify this process, also so that the limited resources available in the sector would be used efficiently (Anaf et al. 2018, Schwartz et al. 2018, Brokerhof 2011, 10).

Several tools were created to assist collection managers in managing their collection. Starting points are vetting the existing conditions in which the collection is kept (e.g. building, building infrastructure, functioning of the organization) and characterizing the type of collection (value, material, condition) (Brokerhof 2017, 9). On this basis, further work is done to identify risks that may threaten the proper long-term preservation of the heritage to ultimately encourage collection managers to take measures that would reduce the main risks. Tools for this risk analysis have also been developed as a guide (Elkin 2011, 12).

Other tools aimed to address a specific collection type and evaluate the risks of only one material or object type (Pedersoli and Reißland 2003, Karsten et al. 2013).

When approaching the series of the seven Enclosed Gardens in the ARTGARDEN project, it was decided to apply the same approach, but tailored to these kind of objects. That is, the analysis is not applied at collection level, but at object level, which implies a kind of scaling down. On the other hand, the scope is specifically focused on objects that include multiple materials or, in other words, are mixed-media objects.

Focusing on mixed-media objects makes visible an aspect hitherto underexposed in risk analysis of heritage collections: the possible interactions between different materials of the same object. Within ARTGARDEN, these physical or chemical interactions that can lead to damage are not considered separately from damage caused by environmental factors, but are included in the risk analysis. The lack of specific knowledge about the mixed-media nature of heritage objects increases the likelihood of damage to these types of objects (Tullock et al. 2021, 6, Fairhurst 2011, 5).

The AGATO tool should provide a practical answer for the large group of people faced with the task of managing historical mixed-media objects by providing recommendations for preventive conservation, adapted to their collection pieces and referring to existing useful resources. By making AGATO English-speaking, we hope to succeed in the aim of providing an answer to a universal problem. Via the online tool and the project knowledge gained by the ARTGARDEN team, we can additionally better reach and help our Belgian colleagues as well as federal institutions with historical mixed media collections. Both the Musical Instruments Museum, Art and History Museum, Royal Museum for Central Africa, Royal Belgian Institute of Belgian Natural Sciences, Royal Library of Belgium but also the War Heritage Institute own and vouch for the proper preservation of thousands of these types of objects and collections.

ARTGARDEN is an interdisciplinary network research project involving many disciplines : conservation-restoration, art history, anthropology, art-technical research, scientific imaging, digital imaging and image processing, conservation science, collection management & care, museology, preventive conservation, Cultural Heritage Risk Assessment, web developing… In this capacity, ARTGARDEN aims to be an example of micro-research on case studies whose sharing via an online free-use and user-friendly tool aims to cause macro-impact.

4. SCIENTIFIC RESULTS AND RECOMMENDATIONS

4.1 Objective 1

All results of the art historical, art technical & anthropological research, as well as the material-technical research, and research on degradation phenomena & material interactions on the Enclosed Gardens have been published in posters & papers, but are particularly easily accessible for the public on https://agato.kikirpa.be/text/enclosed-gardens-of-mechelen . The results have been used to better understand the investigated issues on the Gardens and helped to finetune the overall concept of the functioning of AGATO. The results were also incorporated into the written sentences when describing a particular risk on a particular material (= outcome for an AGATO user). For instance the interaction of degraded glass beads and corroded brass wires from the Enclosed Gardens was examined by the team of University of Antwerp, and this research was also used to formulate the risk for the material combination 'Brass-Glass' in AGATO.

Information or data on consolidation tests (for treatment) on the Gardens, restoration protocols as well as scientific documentation/imaging (IR, UV, vis. light, Microdome) have all been made accessible and manageable for the partner consortium on a Data Management Platform in Cumulus (Canto), by KU Leuven.

All the aforementioned results and knowledge were also used during an extensive risk analysis for the Gardens. The results of this study are discussed in detail in https://agato.kikirpa.be/download/2_Determining_preservation_conditions_risk-based_approach.pdf as well as in the two other accessible preventive conservation reports and publications on AGATO. Following link contains the complete archaeometric study of the Gardens, partly funded by the King Baudouin Foundation : https://agato.kikirpa.be/download/3_Archeometrischestudie_Comhaire_Anaf_KIKIRPA.pdf.

A risk-based methodology was developed to support the decision making regarding the preservation conditions of historical mixed-media objects in general as for the Enclosed Garden with a Calvary Scene and the Hunt of the Unicorn (Fig. 3).

Fig. 3 : Enclosed Garden with a Calvary Scene and the Hunt of the Unicorn, c. 1510-1530, 124 x 158,5 x 33 cm.

Last decade, risk management approaches received a central position within preventive conservation in general. Well-known methods such as the ABC-method (Michalski and Pedersoli Jr. 2016), the Cultural Property Risk Analysis Model (Waller 2003) or the QuiskScan (Brokerhof and Bülow 2016) are applied to identify, analyse and evaluate the major risks for a collection. The method we propose uses the existing methods and risk terminology as a basis. It guides heritage guardians in estimating the relative importance of the different materials that make up a mixed-media object. It considers the material quantity, its value within the context of the object and its use, and the expected loss of value when exposed to a certain hazard. The outcome offers heritage guardians an objective basis to define compromises in preservation conditions for historical mixed-media objects. Moreover, it allows the comparison of different scenarios in order to select the most appropriate one.

From 2018 on, all seven Enclosed Gardens were to be permanently exhibited in the attic of the renovated museum Court of Busleyden.[1] The museum asked itself the question what the most appropriate exhibition format for the Enclosed Gardens should be. Four scenarios were suggested: in open display, with a protective glazing closing off the cabinet, or in a display case with passive or active humidity control (Fig. 4). To support the museums decision, the risk-based approach was applied (1) to rank the impact level per material and per agent of deterioration in order to formulate preventive conservation recommendations, and (2) to compare the risk level of the four different scenarios in order to select the most appropriate exhibition format.

Fig. 4 : Different scenarios for the permanent exhibition of the Enclosed Gardens : a) open display; b) protective glass pane closing off the cabinet; c) showcase with passive or active humidity control

For each scenario and each agent of deterioration probabilities of damage to occur are then defined. The probabilities are quantified with values between 0 to 1, representing a negligible to a significant likelihood of damage to occur, respectively. A time horizon of 100 years is considered. The quantification is shown in TABLE III.

TABLE III : Quantification of the probability of material damage or loss to occur for the different scenarios and in function of the ten agents of deterioration. 0 indicates a negligible probability, while 1 represents a high probability, i.e., damage is expected to occur within a 100 year time horizon

Scenario	Incorrect T	Incorrect RH	Radiation	Pollution	Physical forces	Fire	Thieves and vandals	Water	Pests	Dissociation
Open display	1	1	1	1	1	0.18	0.63	0.63	0.86	0.63
Protective glass	1	1	1	1	1	0.18	0.18	0.63	0.63	0.18
Showcase (passive)	1	1	1	1	1	0.18	0.18	0.18	0.39	0.18
Showcase (active)	1	1	1	1	1	0.18	0.18	0.18	0.39	0.18

[1] Currently 5 Gardens are not on display due to renovations to the museum's roof, though 2 are still in exhibition (03/2023).

The result for the four discussed scenarios is shown in Figure 5. As intuitively expected, the open display entails the highest magnitude of risk, while the showcase with passive climatization entails the lowest magnitude of risk. The use of such showcase decreases the magnitude of risk with 39 per cent compared to an open display. An actively climatized showcase results in a risk reduction of 37 per cent, while a protective front glazing has a risk reduction of 19 per cent. Based on these results, the museum Court of Busleyden decided to realize a permanent exhibition of the seven Enclosed Gardens in passively climatized showcases.

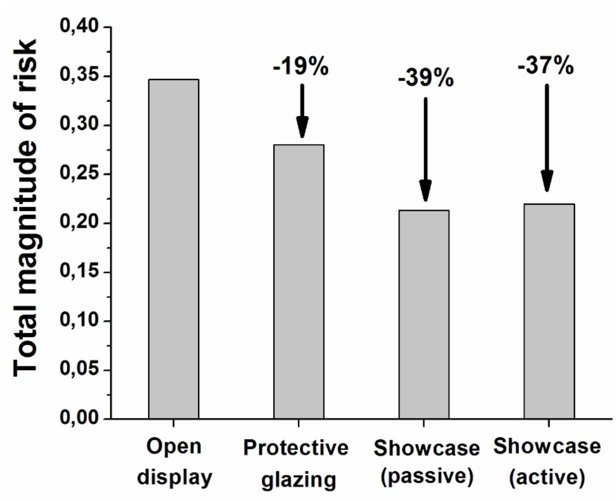


Fig. 5 : Total risk magnitude for the four different scenarios with indication of the percentage risk reduction compared to the scenario with the highest risk magnitude (i.e., the open display).

The methodology allows two main applications. In a first application the impact level is ranked per material and per agent of deterioration. This helps in prioritizing the agents of deterioration that will affect the mixed-media object the most, and detects the most sensitive materials towards each agent of deterioration. This creates an objective basis to define compromises in the preservation conditions for historical mixed-media objects. A second application is the comparison of the risk magnitude for different well-defined scenarios. This allows to select the most appropriate scenario for the preservation of historical mixed-media objects within the possibilities of the objects' owners.

4.2 Objective 2

4.2.1 Developing a (computer-based) management tool : AGATO

Purpose of AGATO

AGATO or the "**A**rt**GA**rden Decision Support **To**ol" aims at assessing a variety of mixed-media heritage objects, such as ethnographic and folk art objects, musical instruments, retables and relics, garments, furniture, manuscripts, etc. These objects are present in large numbers in many collections, abroad as well as in Belgium. AGATO aims to <u>asses in a general way the</u>

risks for historic mixed material artefacts and help the user with recommendations for the daily preventive conservation decisions for the object's preservation. These are based on the user's input of elementary information on the object, on the materials, their condition and environmental conditions. AGATO guides the user in the inspection and observation of his or her object composed of different materials and its environment. By pointing out risks and giving recommendations, AGATO orients the user to potential sources of harm for your object in its environment using the 10 agents of deterioration. It indicates the materials for the user to check and monitor because of their vulnerability in the given environment. The tool should allow the user to have a better look at his or her object, its materials, the visible material degradation and its environment.

AGATO will give many recommendations, but depending on the user's initial motive, and the available resources, he/she has to decide which of the recommendations to actually turn into preventive conservation measures to reduce risks for his or her mixed media object and work towards an improved preservation environment. The more the user knows about his/her object and its environment, the more the recommendations should be adapted to the object.

Who can use AGATO?

The tool is intended for *any museum professional* or *cultural heritage caretaker*. It is available for all persons responsible for the preservation of an object (or a collection) and in charge of taking preservation decisions for that object or all persons legitimately requested to support the preservation decisions.

Whether the user is a preventive conservation advisor taking care of a storage, a curator organizing the loan of an object, a museum technician assisting with the installation of an object in an exhibition, a conservator examining a mixed media object or any other museum professional confronted to a mixed-media object, the tool is there for him/her* to use.

* Preventive conservation advisor; curator; collections manager; conservator (-restorer); collection owner; museum technician; museum volunteer; cultural heritage scientist; collection storage manager; art handlers; preparator; exhibition designer; mount maker; registrar; …

What is an historic mixed material artefact within AGATO?

The tool includes the different materials observed on the 16th century Enclosed Gardens of Malines. Within ARTGARDEN these Gardens were considered as *Historic mixed material artefacts.*

Historic mixed material artefacts are ensembles of two or more historic materials, forming one object that is not to be disassembled. These artefacts can be (functional) objects like for example a book that is composed of several materials such as paper, ink, leather, thread, and glue or an ensemble of clearly distinguishable parts that are intended as one visual entity like the Enclosed Gardens.

Depending on their materials, composite objects may have characteristics of both organic and inorganic materials. The individual materials in the object will react with the environment in different ways. Also, different materials may react in opposition to each other, setting up physical stress and causing chemical interactions that cause deterioration.

Which materials are included in the tool?

Following materials are present in the Enclosed Gardens and incorporated in AGATO:

- Enamel
- Glass
- Leather
- Metal and alloys
    - Brass, Bronze, Copper
    - Gold
    - Iron and steel
    - Silver
- Organic / hygroscopic materials
- Paper
- Parchment
- Stone / minerals
- Textile
    - Silk
    - Wool
- Wax
- Wood
    - Painted wood

This list of these materials outlined the boundaries of the overall project. More recent or modern materials, like synthetic materials or modern alloys are therefore not included (in AGATO) at this point so their specific risks and recommendations are not (yet) available.

What is the concept of AGATO?

The overall concept for AGATO is shown in the diagram below (Fig. 7 + Annex 1). It consists of 3 main parts: user´s input, knowledge base query and output. In the first part, users will provide input to characterise their mixed-media objects and the environment in which they are kept. This input will then be used to search the knowledge base for the relevant information on material-environment and material-material interactions that can possibly damage the object. 'Risk warnings' concerning these potentially harmful interactions for the object at hand, together with recommendations to mitigate each risk that has been identified, will be provided as outputs to the user.

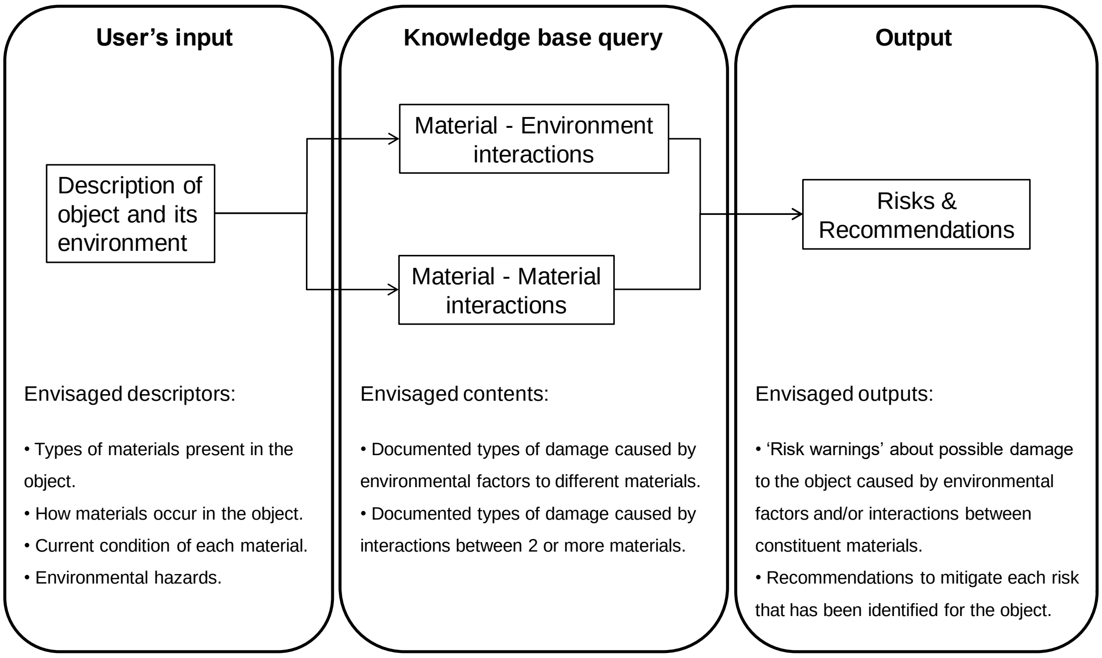


Fig. 7 : Overall concept for AGATO (by José Luiz Pedersoli Jr., 2018)

Walk-through the AGATO process – users guidelines (for the extended version see Annex 3):

Input expected from the user:

- Make login (e-mail required, further information not mandatory)
- Name the object to start an assessment
- Upload a photo (not mandatory)
- A progress bar displayed from the start of an assessment visually accompanies the fill-out process and allows to move back and forth
- Identify materials
- Rank materials according to significance and / or prevalence
- Identify material combinations and the way they are combined (not mandatory)
- Identify materials that are enclosed together (not mandatory)
- Identify condition of each of the materials and of the materials directly touching another material. Number tags can indicate the locations on the picture. Extra pictures (for instance of details) may be added.
- Answer 18 questions about environmental hazards related to the 10 agents of deterioration
- Check overview of answers
- View the results

Results can be viewed in three ways:

- First and overview of the agents of deterioration identified in the assessment, ranked by importance (visible by colour scale). Clicking an agent in the list gives an overview of ranked risks specifically for that agent and general information about the agent.
- Secondly, the materials present in the object are listed (as the user has ranked them). Clicking a material in the list gives an overview of ranked risks specifically for that material.

- Finally, all risks identified (for all materials and all agents present) are ranked according to the magnitude of the risks.
- Every risk describes the possible degradation of a material due to exposure to a certain agent of deterioration. Recommendations are given to avoid this degradation, to block the agent of deterioration to reach the material, to detect the presence of the agent and to respond in case the material was affected by the agent of deterioration. The same goes for material combinations.
- Every 'risk & recommendation' that is shown, mentions also 'learn more'. Clicking 'learn more' leads to the bibliographical references that are used and may be useful for further reading.

The output can be interpreted in two ways:

- The risk of loss of value is shown when the user ranked the materials according to 'significance' in the first step and when the slide-button on the result-page is set on 'significance';
- The risk of losing material important to the structure of an object is shown when the user ranked the materials according to 'prevalence' in the first step and when the when the slide-button on the result-page is set on 'prevalence'.

The output-page offers different possibilities:

- Results can be viewed in a 'compact' way, only the titles of the ranked risks are mentioned to allow a better overview. A user may choose to slide the button between 'extended' and 'compact';
- The object can be duplicated to create a 'copy of the object' including all information filled out earlier. This may be used to compare different situations, for instance difference in possible risks to the object when it is conserved in another environment (storage, exhibition, display case,…), or the difference for an object before or after a conservation treatment. In that case answers can easily be adapted using the 'overview' by clicking an environmental hazard to be directed to the question and modify the answer;
- Using 'edit object' more (curatorial) information on the object can be registered, administrative data such as the inventory number, owner, iconography, dimensions, repository,… (not mandatory);
- Results of every assessment are saved within a user's account, on the server of KIK-IRPA, only visible to its administrator. Objects or assessments are not accessible to the public;
- To use the results of an object assessment, they can be exported by using the 'print' button and create a pdf. All administrative data filled out in 'edit object' will be used as a header for this pdf.

A secondary goal has been reached

AGATO also provides single material Risk Assessments (RA) and acts as an overall reference database of ARTGARDEN and RA and preventive conservation in general.

4.2.2 In-depth case study for ARTGARDEN and AGATO: Casket for the crown reliquary of Holy Thorns

Within the ARTGARDEN research, several mixed-media objects were examined as case studies. The case study of the casket for the crown reliquary of Holy Thorns gave rise to in-depth research by each of the partners.

Art historical research has shown that the casket very likely stems from the same period and region as the very valuable crown-reliquary of the Holy Thorns: the Parisian area at the beginning of the 13th century. It was probably custom-made to conserve and eventually transport the crown-reliquary. This profane object merely has a practical function but is mainly of interest for its enamel medallions. The octagonal shaped box is constructed with oak wood, thick brownish leather, held in place with round headed, decorative, copper alloy nails of three different sizes, placed symmetrically. Twenty-five enameled roundels decorate the box, two on each of the eight sides and, nine on the lid of the box, and one more rectangular enamel plaque at the lock of the box. The discs are copper gilt champlevé enamel with engraved and gilded figurines surrounded by a lapis blue background (in different hues). This type of enameled discs, originally from Limoges, were produced in series and commercialized in Europe since the late 12th century.

This coffret can be placed alongside several other (reliquary) coffins from the same period, notably the box of Saint Louis conserved at the Musée du Louvre and the rectangular leather coffret conserved at the Metropolitan Museum of Art.

Apart from the crown-reliquary being mentioned in inventories in the 14th and 15th century, not much is known about the history of the coffret, the precise history since the production of the coffret in the 13th century until the late 19th century remains unclear. In that period, is was exhibited at two exhibitions in 1880 and 1888. (for more information : https://agato.kikirpa.be/text/casket-for-the-crown-reliquary-holy-thorns) Little could be retrieved about the historical storage conditions of the box.

The laboratories of KIK-IRPA identified the constituent materials at but also looked at the damage phenomena present.

MA-XRF made clear that the medieval enamels have a composition comparable to that of the Roman period. The metal support is a gilded copper plate, the gold being applied by 'amalgam gilding'. The presence of a thin gold layer is less evidenced on some parts of some medallions, probably as a result of wear.

All enamels contain cobalt(oxide) as blue colorant. Calcium antimonate and tin oxide are historically the most used opacifiers. The blue enamels on three of the medallions contain antimony but no tin, these enamels could be dated as early 13th century

MA-XRF analysis of the decoration band at the border of the box unveils the wrapped thread and the flat lamella are both made of brass. The wrapped thread is made of a metal strip wound in S-direction around a white textile core yarn from flax. MA-XRF analysis indicated a different copper/zinc ratio for the flat lamella and the wrapped thread. This is reflected in a color difference as shown by the Hirox images. The SEM-EDX analysis allowed to study the elemental composition of metal and also shows the presence of corrosion of copper.

The Hirox images clearly indicate the presence of iron nails and brass nail heads, soldered onto iron cores. Lead-tin alloy was used as solder material between the nail heads and the nails. The MA-XRF identified both the nails used to fix the copper plates onto the box and some of the nail(head)s used as circular decoration around the enamel medallions are composed of brass.

High Performance Liquid Chromatography and photo diode array detection system (HPLC-DAD) were used to analyze dye compositions. Fiber identification was carried out with optical microscopy under transmitted or polarizing illumination. The red damask silk textile at the inside of the reliquary box has been dyed with Mexican cochineal (Dactylopius coccus species) and tannin. The dye composition of the red silk yarns used in the fabric of the lining of the reliquary box coincides with a fragment of fabric from the Diocesan Museum where the box is conserved. A part of the latter textile might indeed have been used for the re-lining of the box.at the end of the 19th century

Study of the hair pattern showed evenly distributed hair follicles indicating that the original leather was made from cow or calf skins.

Moreover, damage that can occur in mixed-media objects was also considered specifically because two materials damage each other when they collide and a chemical degradation reaction occurs. Indeed, damage caused by a combination of different materials was found in the coffret. In this specific case, the deterioration of this leather is probably a result of the combined effect of mechanical damage (nails used to fix the leather and thus perforating the leather) and damage by climatological conditions (large climatic variations make the leather shrink and expand causing deformations and cracks). (for more information : https://agato.kikirpa.be/download/ARTGARDEN_reliquarybox_LabsKIKIRPA.pdf)

The University of Antwerp worked further on possible harmful effects of gases from materials contained in an enclosed and sealed space, here the inside of the enclosed box. The results obtained by solid-phase microextraction (SPME) coupled to gas chromatography with mass spectrometry (GC/MS), demonstrate that the inside of the reliquary box has volatile compounds that may damage the materials when the lid is closed.

These compounds can be related to the ageing of wood or the degradation of the organic parts of the box and to biodegradation processes (growing of fungi or other microorganisms). The latter are made possible by the conditions found inside of the reliquary box: lack of light and presence of textile, which favors the condensation increasing the relative humidity. The current conditions inside of the reliquary box are not ideal for the preservation of the materials.

For now, the degradation of the silk lining as a result has been limited. However, to prevent long-term deterioration of the silk fibres, it is advisable to prevent accumulation of harmful gases. It would be recommended to decrease the concentration of those compounds for instance by opening the box periodically for ventilation. (for more information : https://agato.kikirpa.be/download/ARTGARDEN_reliquarybox_LabsUA.pdf)

Apart from the above research of the casket by the multidisciplinary team of ARTGARDEN, the actual exhibition and conservation environment of the casket and the possible consequences for interactions of the different materials were analyzed in situ. Indeed, the casket was also the main case study to build the online decision support tool, according to the concept developed in collaboration with an external researcher, José Luiz Pedersoli Jr. (ICCROM), international expert in risk analysis for heritage collections. (Outline of the online decision support tool : see Annex 1)

To put this tool to the test and refine its functionality, it was decided to carry out a risk analysis of the Casket for the crown reliquary of Holy Thorns in situ, in the Musée Diocésain of Namur. The QuiskScan© method (Brokerhof and Bülow 2016), generally used to get a better overview and understanding of the risks to which a collection or subcollection is exposed, was chosen and exceptionally applied to this single object. (for the process of this analysis see Annex 4)

In close collaboration with the museum, the different steps of the QuiskScan were executed to map the exhibition environment of the object. To obtain a complete overview of the situation, all of the 10 agents of deterioration are taken into account: physical forces, incorrect temperature, incorrect relative humidity, fire, water, biological agents, light (and UV and IR radiation), theft and vandalism, dissociation and pollution.

The characterization of the object is the core of the process, as the different materials each have their own specific vulnerability. In the next step, their relative value is defined in relation to the other materials. Then, all risks are analyzed according to the vulnerability of each material and the possible exposure to any of the 10 agents of deterioration is determined. Together, these two parameters contribute to formulate the risk level. Ultimately, they are combined with all assembled data to understand where the risk of loss of value is the biggest in the collection and how much of the collection would be lost in that case.

The assembling of the data necessary to perform a QuiskScan calls for an important dialogue with the museum. It compiled a 125 questions interview with the conservator and an extensive documentation campaign. The exhibition room of the casket was photographed, and its floorplan was drawn. The room, all fixtures, the exhibition furniture, the technical equipment and location of the collection and subcollection were indicated. In an additional layer, the exposition to risks linked with each agent of deterioration was mapped.

A modest measuring campaign was set up to support and complete the date gathered during the interview. A datalogger registered both temperature and relative humidity inside and outside the display case of the casket. A second datalogger was installed to measure light and UV radiation. Punctual measurements of light and UV-radiation were systematically taken on the occasion of two different visits.

The results of the QuiskScan finally allowed to put former concerns into perspective and focus attention to more pressing issues. Light intensity, for instance, didn't proof to be a major concern. Continual measurement of light- and UV-radiation permitted to better appreciate the effects of a basic mitigation action that was put in place. The data clearly showed that with the textile cover light levels were sufficiently reduced to obtain a safe environment for the casket during the period of the measuring campaign.

The whole analysis pondering all risks against each other, provided a reliable reference to test the functionality of the AGATO tool. The automated analysis should eventually grant its user the same risk ranking and allow guidance when it comes to taking decisions on the preventive conservation of a historic mixed media artefact.

In this case, both the labor-intensive QuiskScan and the automated analysis from AGATO pointed to the main risk of loss of value by a fire, and by wrong relative humidity (Fig. 8).

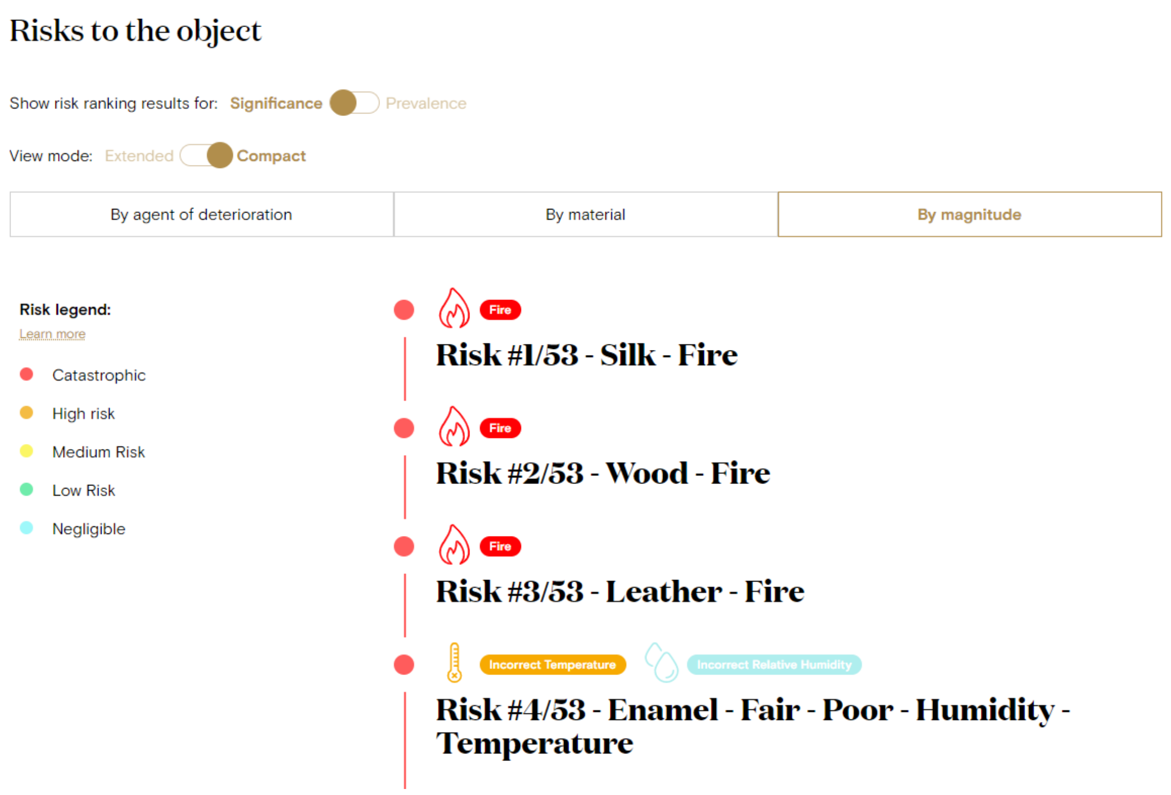


Fig. 8 : Outcome page (risks to the object) for the AGATO test case 'Casket for the crown reliquary of Holy Thorns'

In parallel with working on a user-friendly front-end for AGATO – in collaboration with the external developer Multimedium – an underlying database was also set up. In a first phase, the constituent elements were determined, in a second phase how they should interact with each other to obtain an adequate risk analysis. Extensive discussion was required in setting up this functional skeleton for AGATO to ensure that the right terms were available for each search in the database and also that a correct calculation could be made for the final ranking of the risks (for details on the developer's Risk Selection & Ranking see Annex 2). In this content management system (CMS), heritage risk analysis terminology and parameters were matched with input fields. (Fig. 9)

Moreover, the CMS meets additional requirements: linking bibliographic references and images to the various elements, keeping an overview of the content that has been added, a structure that makes it possible (in time) to translate the content of the fields and to be able to modify and supplement all content at any time with recent findings. Moreover, the CMS can be completed by different employees (without IT experience).

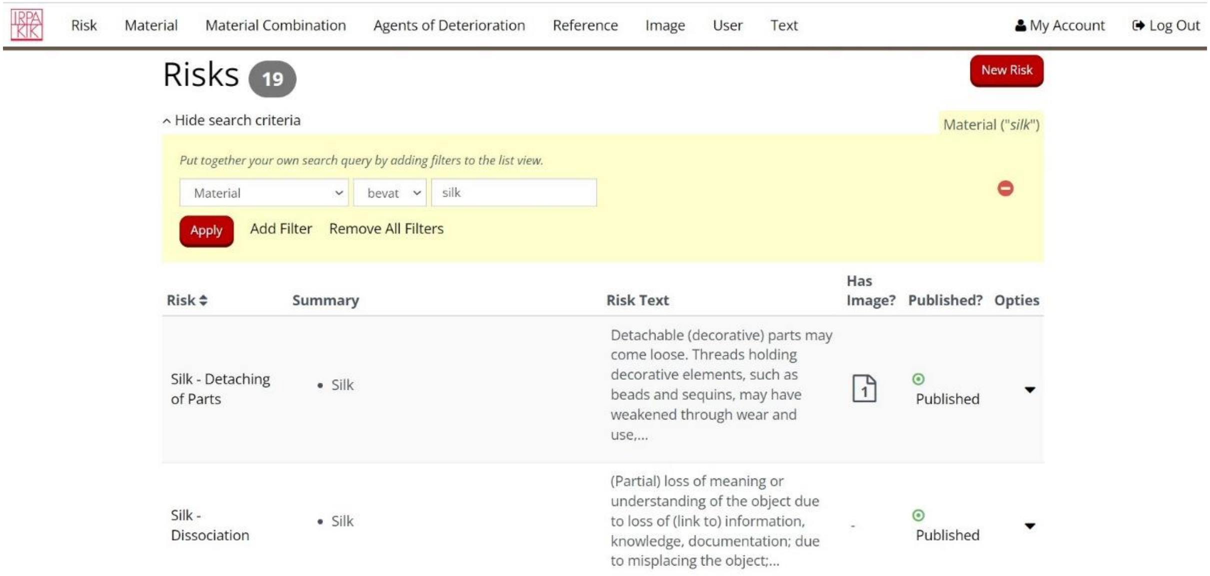


Fig. 9 : Screenshot of the Content Management System (CMS) for AGATO

To make the AGATO prototype work, the necessary content was also entered into the CMS. More specifically, this included the description of 10 agents of deterioration, 18 related questions and 18 materials (present on the Enclosed Gardens and the Casket). For each of these 18 materials, a concise text describes each risk: the potential impact of an effect by an agent. In addition, recommendations are also written out (according to the 'stages of control') to avoid damage, block the agent, detect it and react in case damage has occurred, each time with corresponding bibliographic reference. The almost 400 risks and 1600 recommendations described also include the damage patterns specific to the 35 material combinations included in the CMS.

4.2.3 Future prospects

The CMS can be extended to include risks and recommendations for additional materials and material combinations as well as translation of all information. Initial feedback indicates that users would also like to see the current offering expanded or refined. Hence, whether this potential and the sustainability of AGATO can be elaborated in a follow-up project is also under consideration.

5. DISSEMINATION AND VALORISATION

5.1. AGATO as the main communication channel

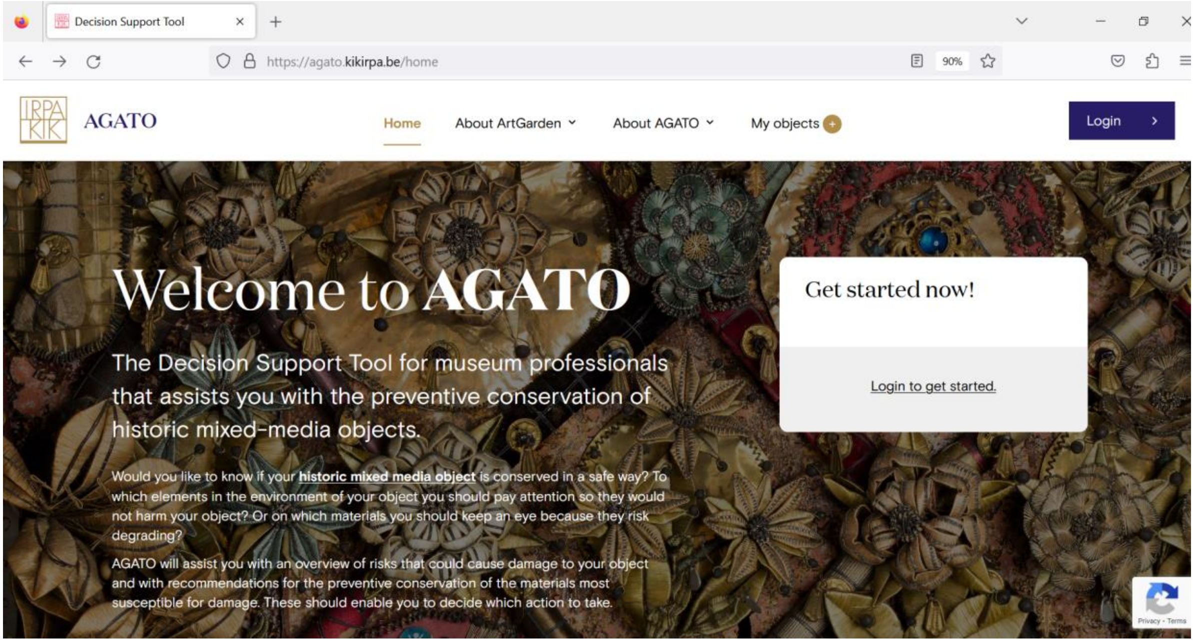


Fig. 10 : Homepage of AGATO

Demo of AGATO : https://youtu.be/hYR7Q2Ni6e0

The online AGATO website is the flagship of the ARTGARDEN project. For its development, the consortium worked in close collaboration with https://www.multimedium.be/. Besides presenting the project, the partners and the follow-up committee involved in its realization, the website features the study of the ARTGARDEN research corpus (12 ARTGARDEN study cases including the 7 Enclosed Gardens of Mechelen) and acts as the main dissemination and valorization channel of the project. But most importantly, it is a tool offering free online decision support for heritage caretakers worldwide.

The website can be consulted here https://agato.kikirpa.be/home, and users are able to navigate through the different tabs. For each ARTGARDEN case study, the images and description of the object are linked to its art historical background, material technical research results and bibliography. Users have access to downloadable PDF research reports that result from the investigations executed within ARTGARDEN.

AGATO is a free online decision support tool. The use of the actual prototype is intentionally kept free, to give anyone managing a collection of objects the chance to introduce their particular objects and get an assessment of the risks their object runs according to their specific environmental situation based, on the 10 agents of deterioration.

Users will find all necessary background on AGATO and all the references used to feed AGATO’s knowledge database, as well as FAQ, in the tab ‘About AGATO’.

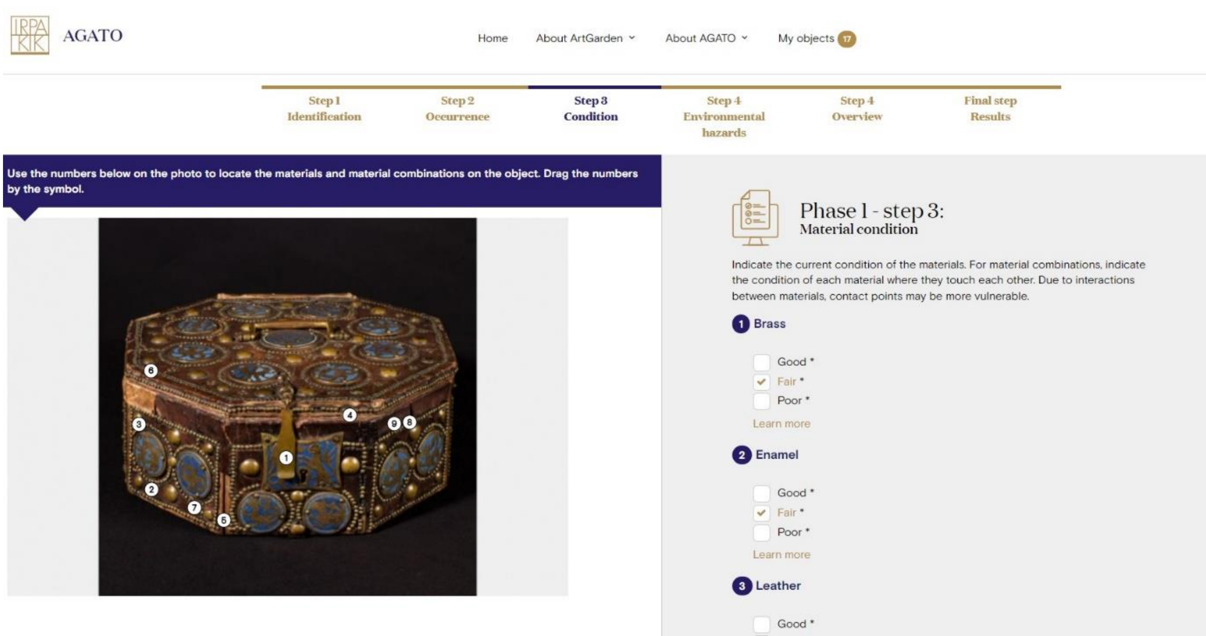


Fig. 11 : Screenshot of AGATO during input process by user

For user guidelines, cfr. Supra 4.2.1 and Annex 3 for the extended version of the *Walk-through the AGATO process.*

5.2. Official launch of AGATO and official closing moment of ARTGARDEN

On December 8th 2022, afternoon, @KIK-IRPA, Brussels, 110 participants

Preceded by AGATO demo for Belspo (16/11/2022) and Directory Board SFI's (25/11/2022)

Program of the official launch:

13.30 uur: Onthaal
14.00 uur: Welkomstwoord door Hilde De Clercq, Algemeen Directeur a.i. van het KIK
14.10 uur: Toelichting bij het project door Marjolijn Debulpaep (KIK) en Lieve Watteeuw (KU Leuven).
14.25 uur: Arnaud Vajda, Voorzitter van de POD Wetenschapsbeleid (BELSPO)
14.35 uur: Demo van AGATO door Elke Otten (KIK), gevolgd door Q&A.
15.15 uur: Receptie

Fig. 12-14 : Official launch of AGATO at KIK-IRPA : Arnaud Vajda (Belspo President), Hilde De Clercq (Director KIK-IRPA), Elke Otten & Marjolijn Debulpaep (KIK-IRPA)

Communication channels :

https ://twitter.com/kikirpabe/status/1602315436254806021,
https ://twitter.com/kikirpabe/status/1602315435982180359,
https ://www.facebook.com/675840942587514/posts/2235513726620220/,
https ://www.facebook.com/332035389103012/posts/462757309364152,
https ://www.instagram.com/p/CmEmsUkM9FX/,
https ://www.linkedin.com/feed/update/urn :li :activity :7008013366342373376

5.3. Overview of other communication channels used

- Initial project website (not up-to-date anymore, replaced partly by AGATO) : http://gardens.kikirpa.be

- Website on the conservation-restoration of the Enclosed Gardens: https://beslotenhofjes.com/

- Communication on websites by partners:

- KIK-IRPA
  - https://www.kikirpa.be/en/projects/artgarden-research-closed-courtyards?lang=en
  - https://www.kikirpa.be/nl/projecten/artgarden-onderzoek-mechelse-besloten-hofjes?lang=nl
  - https://www.kikirpa.be/fr/projets/artgarden-etude-des-jardins-clos-de-malines?lang=fr
  - https://www.kikirpa.be/en/conservation-restoration/preventive-conservation-unit
  - https://www.kikirpa.be/nl/conservatie-restauratie/cel-preventieve-conservatie?lang=nl
  - https://www.kikirpa.be/fr/conservation-restauration/cellule-conservation-preventive?lang=fr

- KU Leuven :
  - Illuminare website
    http://www.illuminare.be/2019/10/18/published-enclosed-gardens-of-mechelen-late-medieval-paradise-gardens-revealed/
  - Projects Illuminare
    http://www.illuminare.be/project/past/
  - Facebook
    https://es-la.facebook.com/illuminare.kuleuven/photos/out-now-the-new-book-enclosed-gardens-of-mechelen-late-medieval-paradise-gardens/1931630023624480/
  - Vimeo
    https://vimeo.com/118596740
  - Faculteit Letteren
    https://www.arts.kuleuven.be/nieuws/besloten_hofjes
  - Hof van Busleyden
    https://vriendenhofvanbusleyden.wordpress.com/2017/02/06/buitenlandse-belangstelling-voor-de-besloten-hofjes/
  - Video capture of the imaging of the Gardens with the Microdome
    https://www.youtube.com/watch?v=w1xG1dQiHRs&

- UA :
  - https://www.sciencelink.net/nieuws-and-verdieping/met-infrarood-speuren-in-eeuwenoude-besloten-hofjes/20687.article

- Belspo website : Thematic areas – BRAIN-be – Research and applications – Belgian Science Policy (belspo.be)

- Science Connection Magazine 56 : 56sci_nl.pdf (belspo.be)

- International symposium "Imaging Utopia: New Perspectives on Northern Renaissance Art. Twentieth Symposium for the Study of Underdrawing and Technology in Painting", Mechelen & Leuven, 11-13/01/2017, Illuminare – University of Leuven Programme | Imaging Utopia: New Perspectives on Northern Renaissance Art (wordpress.com)

- Expert meeting of the International Follow-up Committee: January 24th 2019, KIK-IRPA, Brussels (to overview the members: https://agato.kikirpa.be/text/project)

- Visit with the members of the International Follow-up Committee to the exhibition It almost seemed a lily EN - Museum Hof van Busleyden | Museum in Mechelen : January 25th 2019, Mechelen Hof van Busleyden : In this exhibition Berlinde De Bruyckere juxtaposes and confronts her series with the sixteenth-century Enclosed Gardens (exhibition in partnership with KU Leuven).


Fig. 15-16 : Follow-up Committee members Stefan Michalski (CCI) and José Luiz Pedersoli Jr. (ICCROM) visit the Gardens in Mechelen, guided by Lieve Watteeuw, January 25 2019

- contributions to conferences : see below

COVID affected the nature and frequency of some communication activities.

5.4. Contributions to conferences

Oral presentations

- Anaf, W., Debulpaep, M., Van Bos, M., "The Enclosed Gardens of Mechelen: Preventive Conservation", International symposium "Imaging Utopia: New Perspectives on Northern Renaissance Art. Twentieth Symposium for the Study of Underdrawing and Technology in Painting", Mechelen-Leuven, 11-13 January 2017

- Watteeuw L., "The Enclosed Gardens in focus", International symposium "Imaging Utopia. Study of Underdrawing and Technology in Painting", Mechelen-Leuven, 11-13 January 2017

- Iterbeke, H., "Enclosed Gardens in Late Medieval and Early Modern Texts", International symposium "Imaging Utopia. Study of Underdrawing and Technology in Painting", Mechelen-Leuven, 11-13 January 2017

- Watteeuw, L., Van Bos, M., Vandermeulen, B., "The Mechelen Enclosed Gardens: Imaging and Analyses of three Early 16th-century Mixed-Media Retables during conservation (2014-2016)", International symposium "Imaging Utopia. Study of Underdrawing and Technology in Painting", Mechelen-Leuven, 11-13 January 2017

- Iterbeke H., "Tracing the source: Enclosed Gardens in Late Medieval and Early Modern Texts", International symposium "Imaging Utopia. Study of Underdrawing and Technology in Painting", Mechelen-Leuven, 11-13 January 2017

- Iterbeke H., Vandermeersch J., "Zorg in het kwadraat. De gasthuiszusters en hun Besloten Hofjes." Soirée Lamot. Mechelen, 25 May 2017

- Vanden Berghe, I. and Van Bos, M., "Macro XRF-scanning: New opportunities for non-destructive analysis of the episcopal mitres attributed to bishop Jacques de Vitry (12-13th c. AD), two masterpieces of the Walloon Region", at the Non-destructive and microanalytical Techniques in Art and Cultural Heritage (Technart) International Conference, Bilbao, Spain, 2-6 May 2017

- Iterbeke H., "Reflections of Enclosure in the Image of the Hortus Conclusus: Sixteenth-Century Mixed Media Enclosed Gardens as Visual Communicators." European Association of the Study of Religions Annual Conference. Leuven, 18-21 September 2017

- Iterbeke H., "De productie, functie en betekenis van Besloten Hofjes: een interdisciplinair onderzoek naar historische mixed media (1450-1600)." Doctoraatsseminarie Illuminare. KU Leuven, 20 December 2017

- Iterbeke H., Barbara B., "Beyond *Nonnenarbeit*: Reassessing 'Gender'" in Sixteenth-Century Enclosed Gardens. Gender and Medieval Studies. Oxford University, 8-10 January 2018

- Watteeuw L. & Iterbeke, H., "De Besloten Hofjes in focus", Davidsfonds Academie Mechelen, Hof Van Busleyden, April 2018

- Anaf, W., Van Bos, M., Debulpaep, M., Wei, W., "Vibrational impact on fragile historical mixed-media objects." Presentation at the YOCOCU conference, Matera, Italy, May 23-25, 2018

- Watteeuw, L., Van Bos, M., "The 13th-century Illuminated Parchment Mitre of Jacques de Vitry. History, Illuminations and Art Technical Analyses", Presentation at the workshop "Labs, Art and Relics", Royal Library of Belgium, November 22-23, 2018

- Van Bos, M., Vanden Berghe, I., "Material technical analysis of different materials of the Enclosed Gardens: Non-invasive and invasive analyses mixed-media objects." Presentation at the ARTGARDEN International Follow-up Committee, KIK-IRPA, January 24 2019.

- Watteeuw L., "Art historical research on the Enclosed Gardens", Presentation at the ARTGARDEN International Follow-up Committee, KIK-IRPA, January 24 2019.

- Marchetti, A., Characterization of the metallic elements of 5 panels of the Enclosed Gardens, Presentation at the ARTGARDEN International Follow-up Committee, KIK-IRPA, January 24 2019.

- Anaf W., Debulpaep M., "Preventive Conservation of the Enclosed Gardens: risk assessment", Presentation at the ARTGARDEN International Follow-up Committee, KIK-IRPA, January 24 2019.

- Anaf W., Debulpaep M., Pedersoli Jr. J.L., "Outlines of the Decision Support Tool: preservation of historical mixed-media objects", Presentation at the ARTGARDEN International Follow-up Committee, KIK-IRPA, January 24 2019.

- Lieve Watteeuw and Marina Van Bos, "A manuscript for the head: The 13th-century illuminated parchment mitre of Jacques de Vitry", Presentation at the "Care and Conservation of Manuscripts", 18 conference, University of Copenhagen, 14-16 April 2021

- Vanden Berghe, I., Watteeuw, L. and Vandermeersch, J., "Early sixteenth century Mix-Media Retables: Study and Conservation of the Silk Flowers in the Enclosed Gardens of Mechelen", at the 19th triennial Conference of ICOM-CC, Theme: Transcending Boundaries: Integrated Approaches to Conservation, Beijing, 17-21 May 2021 (online conference)

- A. Marchetti, V. Beltran, F. Borondics, C. Sandt, G. Nuyts, M. Leeuwestein, M. Debulpaep, K. De Wael, Novel optical-photothermal infrared (O-PTIR) spectroscopy for the sub-micron molecular characterization of cultural heritage. Oral presentation at CHEMCH 2022 conference, Ravenna, Italy, July 4-8 2022

- E. Otten & M. Debulpaep, Demo of AGATO for Belspo, KIK-IRPA, 16/11/2022

- E. Otten & M. Debulpaep, Demo of AGATO for Directory Board SFI's, Belspo, 25/11/2022

Poster presentations

- Meert, C., Watteeuw, L., Debulpaep, M., De Wael, K., "ARTGARDEN. Art Technical Research and conservation of mixed-media ensembles: 'The Enclosed Garden'", Poster presentation at the International symposium "Imaging Utopia: New Perspectives on Northern Renaissance Art. Twentieth Symposium for the Study of Underdrawing and Technology in Painting", Mechelen-Leuven, 11-13 January 2017. **uri**: https://orfeo.belnet.be/handle/internal/10904

- Marchetti, A., Storme, P., Nuyts, G., Beltran, V., Watteeuw, L., Debulpaep, M., De Wael, K., "All that glitters is not gold: characterization of metallic decorative elements from five Enclosed Gardens." Poster presentation at the Technart2019 conference, Bruges, Belgium, (May 7-10 2019). **uri**: https://orfeo.belnet.be/handle/internal/10886

- Otten E., Pedersoli Jr. J.L., Anaf W., Debulpaep M., "Preservation of mixed-media objects: An online decision-support tool", abstract & poster presentation: ICOM-CC 19th Triennal Conference 2021 Beijing. Preventive Conservation. China 17-21 May 2021 Theme: Transcending Boundaries: Integrated Approaches to Conservation, postponed from 2020 to 2021 (online)
  uri: https://orfeo.belnet.be/handle/internal/10885 ;
  uri: https://orfeo.belnet.be/handle/internal/10905

5.5. Exhibitions

- temporary exhibition of the Enclosed Gardens in 'In Search of Utopia' in Museum M, Leuven, 19/10/2016 – 17/01/2017 In search of Utopia | M Leuven

- temporary exhibition of the Enclosed Gardens in 'It almost seemed a lily, Berlinde De Bruyckere', Museum Hof van Busleyden, Mechelen, 15 December 2018 – 12 May 2019

- permanent exhibition of the Enclosed Gardens in the new Museum Court of Busleyden, Mechelen (since March 2018)

5.6. Conferences

International symposium "Imaging Utopia: New Perspectives on Northern Renaissance Art. Twentieth Symposium for the Study of Underdrawing and Technology in Painting", Mechelen & Leuven, 11-13/01/2017, Illuminare - University of Leuven :

Programme | Imaging Utopia: New Perspectives on Northern Renaissance Art (wordpress.com)

Imaging Utopia: New Perspectives on Northern Renaissance Art | XXth symposium for the Study of Underdrawing and Technology in Painting | Illuminare – Centre for the Study of Medieval Art (University of Leuven) | 11-13 January 2017 (wordpress.com)

6. PUBLICATIONS

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ANNEXES

Annex 1 : Outline of AGATO, by José Luiz Pedersoli Jr., 2018

Preservation of mixed-media objects - *Decision Support Tool* outline

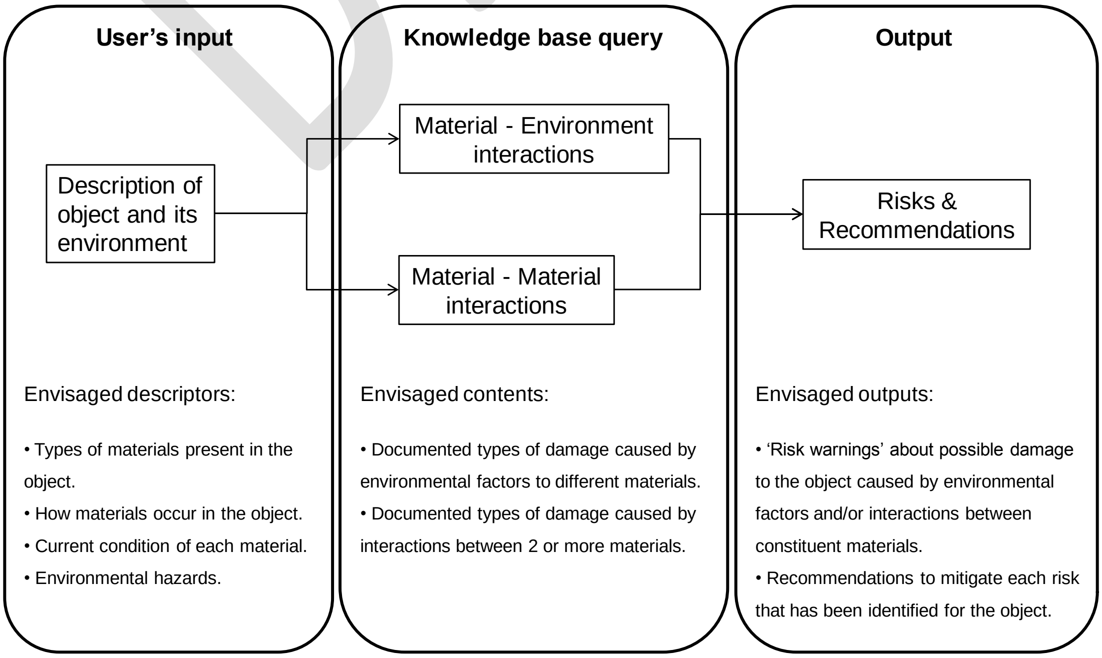
I. Introduction

One of the expected outcomes of the *Art Technical Research and Preservation of Historical Mixed-Media Ensembles: 'Enclosed Gardens'* project led by KIK-IRPA is a (computer-based) management tool to help preserve complex and fragile heritage objects in mixed media. It will do so by providing meaningful information concerning possible risks related to material-environment and/or material-material interactions, as well as possible measures to mitigate those risks. Data from field research, literature surveys, and laboratory experiments to be carried out in the project will be used to generate a knowledge base from which the relevant information can be retrieved, based on the characteristics of the object and its environment inputted by the user. Through a friendly interface, this tool will help users make more knowledgeable decisions about the preservation of mixed-media objects.

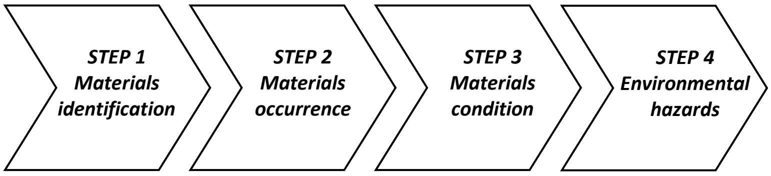
A first outline for the structure and operation of the aforementioned *Decision Support Tool* is presented in this report. It includes a general description of the model components, the required inputs, the organisation and required contents of the knowledge base (database), and the types of output that will be generated.

II. Overall concept

The overall concept envisaged for the *Decision Support Tool* is shown in the diagram below. It consists of 3 main parts: User´s input → Knowledge base query → Output. In the first part, users will provide input to characterise their mixed-media objects and the environment in which they are kept. This input will then be used to search the knowledge base for the relevant information on material-environment and material-material interactions that can possibly damage the object. 'Risk warnings' concerning these potentially harmful interactions for the object at hand, together with recommendations to mitigate each risk that has been identified, will be provided as outputs to the user. A more detailed explanation of each component of the *Decision Support Tool* is presented in the following pages.



II.1. User´s input



1 - Types of materials present in the object: *STEP 1. Materials identification*

Users will be asked to name the materials present in their mixed-media objects, starting from the most prevalent material, then the second most prevalent, and so on until the least common material (using checkboxes or a drop-down menu). If the relative prevalence of materials is not obvious, users can enter them according to their perception. Alternatively, they will be given the option to name the materials according to their relative importance for the object in its context, starting from the most important material, then the second most important, and so on until the least significant. As materials are checked in one of these sequences, the database will number and order them accordingly. At the end of the process, the list of materials present in the object will be shown to the user for confirmation before moving on to the next step. A set of good quality photographs could be available to illustrate different types of materials in mixed-media objects, and facilitate their identification. Whenever possible, links to materials identification aids available online will be provided to the user (e.g., for metals: https://www.canada.ca/en/conservation-institute/services/care-objects/metals/basic-care-recognizing-metals-corrosion-products.html).

Preliminary selection of materials to be included in the tool (in alphabetical order):

- ☐ Blood (dried)
- ☐ Bone
- ☐ Cardboard
- ☐ Ceramics
- ☐ Coral
- ☐ Glass
- ☐ Hair (animal, human)
- ☐ Horn
- ☐ Ivory
- ☐ Leather
- ☐ Metals and alloys
    - ☐ Brass
    - ☐ Bronze
    - ☐ Copper
    - ☐ Gold
    - ☐ Iron
    - ☐ Lead
    - ☐ Silver
    - ☐ Tin
    - ☐ Others
- ☐ Paint
- ☐ Paper
- ☐ Parchment
- ☐ Pearl / mother f pearl
- ☐ Plant parts (flowers, seeds, stems, bark, peat, etc.)

- ☐ Plastics
    - ☐ Cellulose acetate
    - ☐ Cellulose nitrate
    - ☐ Others
- ☐ Rubber
- ☐ Shell
- ☐ Stone / minerals
    - ☐ Alabaster
    - ☐ Jade
    - ☐ Marble
    - ☐ Precious stone
- ☐ Textile
    - ☐ Cotton / linen
    - ☐ Felt
    - ☐ Silk
    - ☐ Synthetic
    - ☐ Wool
- ☐ Wax
- ☐ Wood
- ☐ …

This selection of materials will be validated and updated during the fieldwork for documentation and systematic gathering of evidence on the deterioration of mixed-media objects (see *II.2. Database query, structure, and contents*).

2 - How the constituent materials occur in the object: *STEP 2. Materials occurrence*

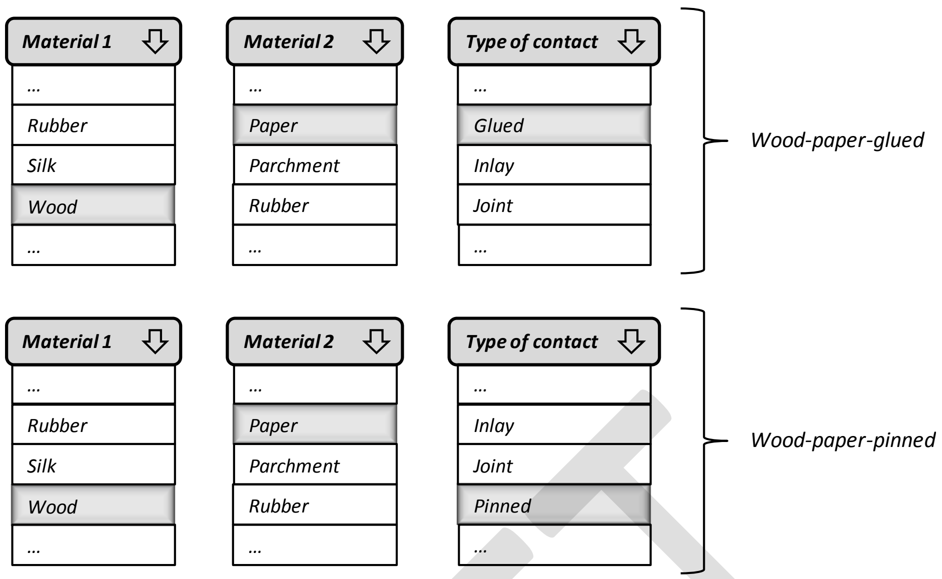
Users will be asked to specify how the materials identified in STEP 1 co-occur in the object, according to the 2 options below. The goal is to identify all possible situations of material-material interactions existing in the object: mechanical stress and/or migration of components within the materials and chemical reactions or transfer at the interface upon direct contact; migration of volatile/off-gassed compounds through the headspace, followed by their deposition, absorption and subsequent reactions.

2 possible types of materials co-occurrence to be considered in the tool:

- In direct contact with another material
- Enclosed in a space together with another material (but not in direct contact with it)

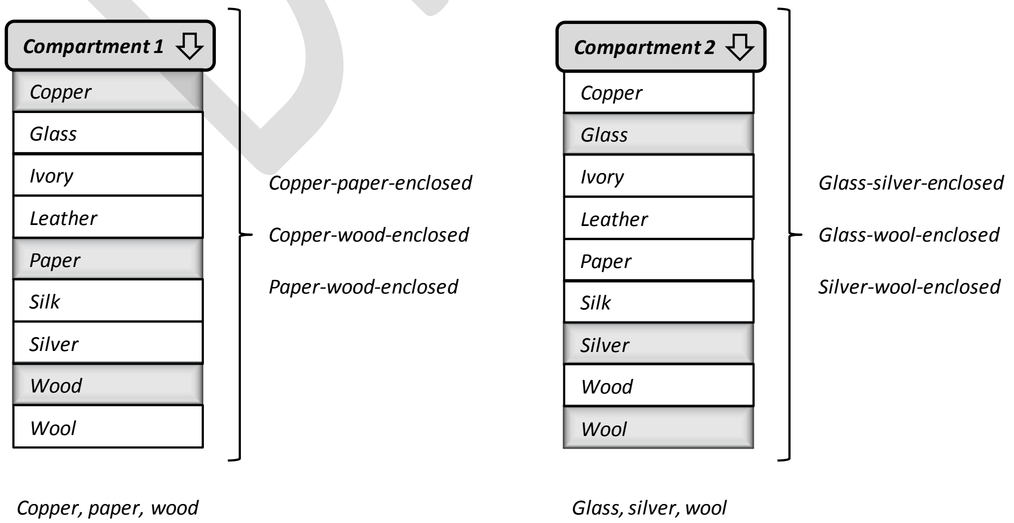
For materials that occur in direct contact with each other, the user will be asked to name them in pairs and specify the type of contact between the two materials (e.g., inlay, joint, glued, nailed, sewn, etc.). This can be done by means of checkboxes or drop-down menus, as illustrated below. Schematic drawings can be provided to help users identify the relevant types of contact between materials. As for the order in which the two materials are named, users may be asked to always name the underlying/support material before the other material sitting on top of it. If two materials occur in direct contact with each other in two or more different ways, the user will be asked to specify each type of occurrence separately (e.g., wood-paper-glued; wood-paper-pinned). At the end of this process, the list of pairs of materials that occur in direct contact with each other will be displayed for checking and confirmation by the user. In principle, material-material interactions will be considered only for pairs of materials. If there is a strong need to do so (e.g. based on evidence gathered during the fieldwork), combinations of 3 or more materials in direct contact can be considered.

Identification of pairs of materials that occur in direct contact with each other in the object (example):



If materials are not in direct contact with each other but enclosed together in one or more compartments of the object, the user will be asked to name all the materials inside each compartment (using checkboxes or a drop-down menu, as illustrated below). Such closed or semi-closed compartments can be, e.g., vials, domes, cases, drawers, and other closed niches that are part of the object itself[1]. At the end of this process, the list of materials that occur enclosed together (not in direct contact) in each compartment will be displayed for checking and confirmation by the user. Later on, the database will automatically generate pairwise combinations for all these materials. In principle, material-material interactions resulting from this co-occurrence in enclosed spaces will be considered only for pairs of materials (e.g., if paper, wood, and copper are enclosed together in the same space, the tool will address the following types of occurrence: paper-wood-enclosed; paper-copper-enclosed; wood-copper-enclosed). If there is a strong need to do so (e.g. based on evidence gathered during the fieldwork), combinations of 3 or more materials enclosed together can be considered.

Identification of materials that occur enclosed together but not in direct contact (example):



[1] Materials that make up the (inner) walls of these compartments should also be considered since they are an original part of the object (e.g., if a complex mixed-media object contains a glass vial inside which other materials are enclosed, glass should also be listed as one of the materials that occur 'enclosed together' in this object).

For each type of occurrence inputted by the user, there will be a field where he/she can enter the corresponding notes and images. This kind of documentation can be particularly useful in the case of large and complex objects with multiple types of material occurrence.

In the specific situation where the entire object is kept inside an airtight, protective enclosure or case (e.g., a glass frame) the user will be asked to inform so beforehand. In those situations, all materials that make up the object will be considered as ‘enclosed together’, and the database will automatically generate the corresponding pairs of co-occurrences. For such objects there will be no need to input any further information on materials that occur enclosed together (not in direct contact) in any compartment of the object, since all possible pairwise combinations will have already been made.

3 - Current condition of each material: *STEP 3. Materials condition*

Users will be asked to score each ‘material occurrence’ identified in STEP 2 for its current condition, using the verbal scale below (checkboxes or drop-down menu). Materials that occur in more than one way will be scored for each type of occurrence (e.g., **wood**-copper-inlay; **wood**-paper-glued; **wood**-paper-enclosed, etc.). In pairs of materials that occur in direct contact with each other, each material will receive one score (e.g., **wood**-copper-inlay; wood-**copper**-inlay). For materials that occur together but not in direct contact inside an enclosed space, each material will receive one score (e.g., **wood**-copper-ivory-enclosed; wood-**copper**-ivory-enclosed; wood-copper-**ivory**-enclosed). If a material is named in STEP 1 but not mentioned in STEP 2, the user will be asked to score its condition individually. This kind of information is relevant since current condition determines the degree of susceptibility of the materials (and the object) to further damage.

Verbal scale to score the current condition of materials in each ‘material occurrence’ present in the object[2]:

- *Good:* no or only minor signs of deterioration/change (e.g., minor fading of colours, minor soiling, minor corrosion, etc.) can be observed in the material (exceptionally well-preserved, new or recently restored objects);

- *Fair:* moderate to noticeable signs of deterioration/change can be observed in the material (e.g., moderate to noticeable fading of colours, soiling, stains, corrosion, embrittlement, abrasion, insect damage, etc.), but it is currently stable (no ongoing deterioration) and still maintains its structural integrity;

- *Poor:* significant losses and/or signs of advanced deterioration (e.g., total or almost total fading, extensive soiling, corrosion, embrittlement, weakening, delamination, warping, breakage, insect damage, etc.) can be observed in the material, which might already have lost its structural integrity (likely to collapse or break when handled).

Sets of images can be provided to illustrate each score above for different types of materials.

4 - Potentially damaging agents: *STEP 4. Environmental hazards*

In addition to inputting information to characterize the object (its materials, how they occur and their condition), users will also be asked to identify potentially dangerous factors in the

[2] If the user does not feel confident enough or is not able to assess the condition of one or more materials (e.g. in case they are covered by other materials), the database will consider it as *fair* by default.

immediate environment where it is kept. This identification will be structured according to the *10 agents of deterioration*, by using simple YES/NO questions as illustrated below.

- Is the object expected to be subjected to extensive handling in the future?

  ☐ YES ☐ NO

- Given the conditions in which the object is stored or displayed, is it likely that it may be affected by impact/shock, vibration, compression or abrasion in the future?

  ☐ YES ☐ NO

- Given the object's monetary/collectible value, its dimensions and the security conditions in the environment where it is kept, is it likely that the object (or some of its parts) may be stolen in the future?

  ☐ YES ☐ NO

- Given the object's symbolic value and the security conditions in the environment where it is kept, is it likely that the object may be vandalized in the future?

  ☐ YES ☐ NO

- Does the environment where the object is kept provide a high level of control against fire (including strict prevention measures, compartmentation, automatic suppression system, well-trained and well-equipped staff)?

  ☐ YES ☐ NO

- Given the existing sources of water (rain, plumbing, wet cleaning procedures) and protective barriers (roof, room, storage/display unit, packaging) in the environment where the object is kept, is it likely that it may come in direct contact with water in the future?

  ☐ YES ☐ NO

- Given the incidence of harmful pests (e.g. insects, rodents) and the existing barriers and other protective measures in the in the environment where the object is kept, is it likely that it may come in direct contact with such pests in the future?

  ☐ YES ☐ NO

- Given the conditions of the environment in which the object is kept and existing protective barriers, is it expected to be exposed to significant amounts of dust in the future?

  ☐ YES ☐ NO

- Is the object going to be exposed to light in the future?

  ☐ YES ☐ NO

- Is the object expected to be exposed to temperatures that are 'too high' (>30°C), 'too low' (<10°C) or to sudden and/or intense temperature fluctuations (>±15°C)[3] in the future?

  ☐ YES ☐ NO

  Has the object already been exposed to these conditions of temperature in the past?

  ☐ YES ☐ NO

[3] The threshold values used here for 'too high' (>30°C), 'too low' (<10°C), and intense temperature fluctuations (> ±15°C) are those mentioned in the specialized literature for physical damage in the most sensitive materials: https://www.canada.ca/en/conservation-institute/services/agents-deterioration/temperature.html.

- Is the object expected to be exposed to conditions of relative humidity >60%[4] in the future?

  ☐ YES ☐ NO

- Is the object expected to be exposed to relative humidity fluctuations of >±10%[5] in the future?

  ☐ YES ☐ NO

  Has the object already been exposed to these levels of RH fluctuation in the past?

  ☐ YES ☐ NO

- Given the conditions under which the existing data, information, and knowledge about the object are kept, is it likely that they may be (partially) lost in the future?

  ☐ YES ☐ NO

- Does the object contain removable/detachable parts?

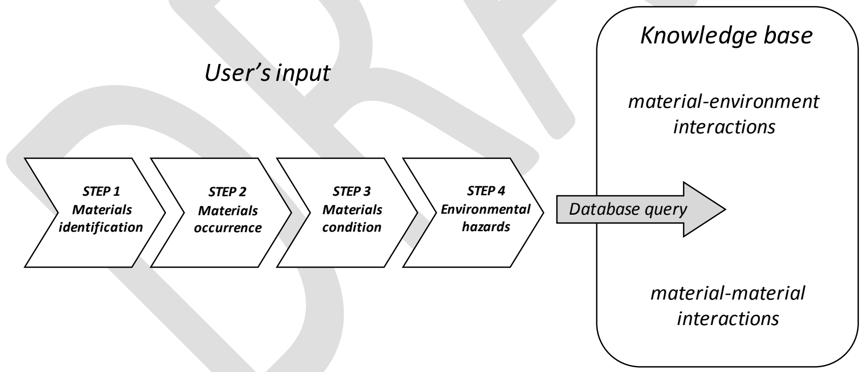
  ☐ YES ☐ NO

  In this case, given the conditions in which the object is kept, is it likely that those parts may be lost in the future?

  ☐ YES ☐ NO

A user-friendly interface will be designed and validated to optimize the inputting process for the target users of the *Decision Support Tool*.

II.2. Database query, structure, and contents



The information provided by the user on STEPS 1-4 (User´s input) will be used to search the knowledge base for known (and well-documented) material-environment interactions, as well as material-material interactions.

Each 'string' of *materials-occurrence-condition-environment* automatically generated from the inputs provided in STEPS 1-4 will serve as a reference/label to find the pertinent information in the database, which will be organized according to these labels for all possible combinations.

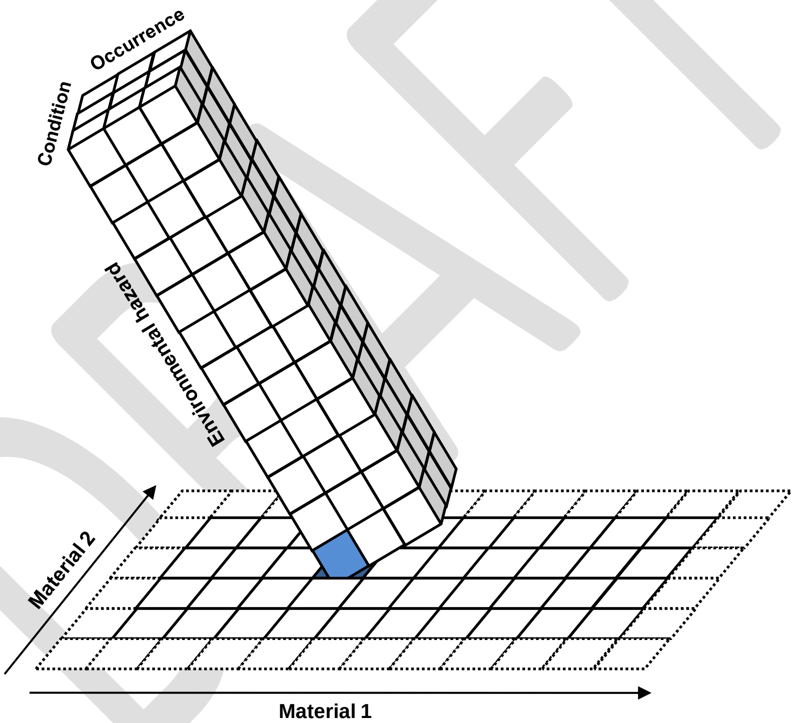
[4] RH threshold level for mould growth on sensitive materials, mentioned in the specialized literature: https://www.canada.ca/en/conservation-institute/services/agents-deterioration/humidity.html

[5] RH fluctuation threshold level for mechanical damage on highly sensitive materials, mentioned in the specialized literature: https://www.canada.ca/en/conservation-institute/services/agents-deterioration/humidity.html.

For instance, the following ‘strings’ may be generated for a given object:

- ***wood***-*paint-polychrome-fair-RH fluctuation(proofed)*
- *wood-**paint**-polychrome-poor-RH fluctuation(proofed)*
- ***wood***-*lead-enclosed-fair-pests*
- *wood-**lead**-enclosed-poor-pests*

The relevant information on material-environment and material-material interactions for each ‘string’ will be presented to the user in the form of standardized ‘risk warnings’ with illustrated examples, references, and recommendations to mitigate each risk (see section *II.3. Output to users*). The database can be envisaged as having a 5-dimensional structure with the following dimensions: *material1*, *material2*, *occurrence*, *condition, environmental hazard*. Each ‘point’ in this 5-dimensional space will be a cell containing the relevant data and pertaining references to be returned to the user for each combination of those 5 variables, provided as input. A visual representation of this structure is shown in the diagram below.



Three main sources will be used to populate this knowledge base:

1. Systematic documentation of mixed-media objects (field research);
2. Technical and scientific literature (heritage science, materials science);
3. Laboratory experiments carried out within the project (e.g. accelerated ageing of materials and combinations of materials under different environmental conditions: light/UV, pollutants, temperature, relative humidity).

For the documentation of mixed-media objects, a protocol will be developed to ensure that all relevant data are acquired in a systematic way. This documentation will cover as many objects and collections as possible, aiming at providing a meaningful and representative sample of (Belgium) mixed-media movable heritage. The data and information to be collected include:

- Relative prevalence of different individual materials, as well as pairs of materials that occur in direct contact with each other or enclosed together in the same space (without being in direct contact), in mixed-media objects. This information will help decide the order in which the database will be populated, from most prevalent to least prevalent materials.

- Photographic records to document and illustrate the occurrence of individual materials, as well as pairs of materials that occur in direct contact with each other or enclosed together in the same space, in mixed-media objects. These images can be used to help users identify the materials and their occurrence in their own objects when using the tool.

- Photographic records to document and illustrate all types of deterioration phenomena observed in individual materials, as well as in pairs of materials that occur in direct contact with each other or enclosed together in the same space, in mixed-media objects. Besides the photographic records, whenever available, information about the (possible) impact of environmental conditions on the observed deterioration phenomena will be systematically collected. This documentation will serve as evidence to support the development of 'risk warnings' for similar situations, which will populate the corresponding cells of the database. The pertaining photographs will be part of this output, making it possible for the user to visualize the expected impact in each case. If significant deterioration phenomena that undoubtedly results from the simultaneous interaction between three or more materials are observed, they will also be properly documented. In this case, the corresponding information, 'risk warnings', and images will populate specific additional cells that will be created in the database for that purpose.

A thorough bibliographic survey will be carried out using well-known resources dedicated to the heritage sector (e.g. AATA, BCIN, ICCROM library, CCI´s page on agents of deterioration)[6] to look for relevant information and references on deterioration phenomena resulting from material-environment and material-material interactions, as well as on their prevention and remediation. Together with the evidence collected through field research, the results of this bibliographic survey will support the development of 'risk warnings' and risk reduction recommendations to populate the corresponding cells of the database. Materials science resources beyond the heritage sector will also be consulted to help populate the knowledge base.

The third source of data to populate the knowledge base will be a series of laboratory experiments carried out by the project partners to address still unresearched, undocumented, or poorly understood material-environment or material-material interactions. The experiments will consist of artificial ageing of single materials and/or pairs of materials - in direct contact with each other or enclosed together inside a container - simulating different types of occurrence in mixed-media objects. Ageing conditions will include controlled exposure to hygrothermal (RH, T), light/UV, and/or gaseous pollution stresses to simulate possible environmental conditions in different storage and display scenarios. Test samples will be systematically documented for any type of deterioration observed in the experiments. The results will support the development of 'risk warnings' to populate the corresponding cells of the database. Selection of ageing conditions, materials and configurations for the test samples will be based on their relative prevalence in actual mixed-media objects and their storage and display environments (field data), as well as on clearly identified knowledge gaps (literature survey). This will ensure that meaningful new knowledge will be generated at the end of the project.

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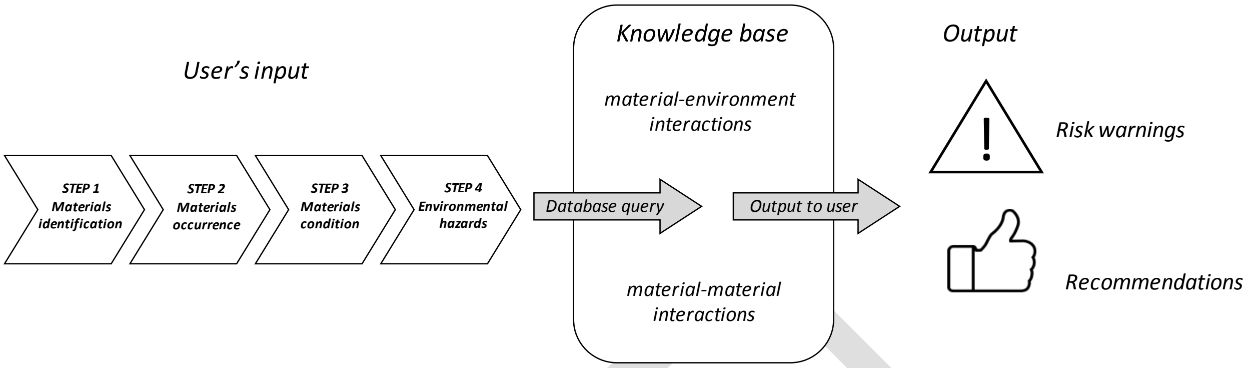
[6] www.aata.getty.edu, www.bcin.ca, www.iccrom.org/library, https://www.canada.ca/en/conservation-institute/services/agents-deterioration.html.

It is envisaged that the process of populating the knowledge base will be able to continue beyond the duration of the project, so that it can be continually updated and improved as new information is found and new knowledge is generated about the preservation of mixed-media objects.

II.3. Output to users



The output of the *Decision Support Tool* will be a series of standardized warnings with illustrated examples, references, and recommendations to mitigate each risk documented in the knowledge base for the combinations of *materials-occurrence-condition-environment* inputted by the user.

The 'risk warnings' will be ordered by material, starting from the most prevalent/significant until the least common/relevant material in the object, as inputted in STEP 1. For each material, the warnings will be ordered from the typically most relevant (biggest) risk until the least relevant (smallest) risk, taking into account how the material occurs in the object, its current condition, and the expected loss of value resulting from each type of material-environment and material-material interaction[7]. Risks will be labeled according to the corresponding agent of deterioration. Risks that result from material-material interactions will be clearly identified so that the user knows exactly to which specific co-occurrence(s) in the object they are associated.

The risk reduction recommendations will be developed and labeled according to *5 stages of control*: AVOID, BLOCK, DETECT, RESPOND, RECOVER. These are a logical sequence of actions to mitigate risks by (preferably) avoiding their cause, blocking, detecting and (when necessary) responding to the presence and damaging action of the agents of deterioration, and recovering from any eventual damage/loss suffered by the object if everything else fails. The main focus of the *tool* will be on preventive conservation measures, i.e., AVOID, BLOCK, and DETECT. Nevertheless, reactive measures will be recommended whenever relevant. Recommendations will be clear, up-to-date, practical, and achievable for all or most users. Interdisciplinary consultation with conservation and communication experts will be carried out when developing the recommendations in order to maximize their efficacy and understanding.

A simplified overview of all risks and recommendations for the object will be presented at the end to summarize the results of the output. In this summary, risks will be ordered from largest to smallest for the object as a whole[7]. This ranking will be based on whether the entire object

[7] Although the level of risk results from the combination of *probability/rate x expected impact*, for practical reasons the ranking of risks by the *tool* will be based only on the (typically) expected loss of value in the material/object, i.e. assuming equal/comparable probability or rate for all events or deterioration processes.

or only some of its materials (and which ones) are expected to be affected by each risk, and the loss of value to the object as a whole estimated in each case. Risks that typically result in total or almost total loss of the object (e.g. theft, fire) will appear first. Risks expected to cause significant damage to multiple materials present in the object, including those of higher prevalence/significance, will follow. Risks estimated to cause only small damage to one or few materials of low prevalence/significance in the object will appear as the last ones. The relative prevalence/significance of the materials affected by a given risk, together with the rank order of that risk for each one of those materials, will be used by the database to define the order in which to present the risks to the object as a whole, and corresponding recommendations[8].

An illustrative example of the envisaged type of output discussed above is presented in the following pages. This example refers to the occurrence of copper, glass, silver, wool, and wood in a hypothetical mixed-media object. The order of significance of these materials informed by the user was: 1) silver, 2) copper, 3) wool, 4) wood, 5) glass. Silver and wool occur enclosed together inside a glass vial (without being in direct contact with each other). Copper and wood co-exist in direct contact with each other, as a metal inlay on wood. The current condition of these materials is as follows: 1) silver-good, 2) copper-fair, 3) wool-fair, 4) wood-good, 5) glass-good. The environmental hazards indicated by the user were: excessive handling, theft, pests, dust, light-UV, and high RH.

USER´S INPUT:

STEP 1 Materials identification	*STEP 2 Materials occurrence*	*STEP 3 Materials condition*	*STEP 4 Environmental hazards*
1. Silver 2. Copper 3. Wool 4. Wood 5. Glass	Silver-wool-glass-enclosed Wood-copper-inlay	**Silver**-wool-glass-enclosed-good Silver-**wool**-glass-enclosed-fair Silver-wool-**glass**-enclosed-good **Wood**-copper-inlay-good Wood-**copper**-inlay-fair	Excessive handling Theft Pests Dust Light-UV High RH

OUTPUT:

I. SILVER

Criminals: theft of the object or its silver elements. [link to illustrated examples]

• Avoid conditions that facilitate theft: object unattended and/or easily within reach; visitors carrying bags or other belongings where small objects or their parts can be easily concealed.
• Block the access of thieves: effective barriers at the building, room, and storage/display unit levels.
• Detect the presence of thieves or attempted thefts: alarm, CCTV, security guards.
• Respond to theft attempts: clear response procedures; well-trained staff.
• Recover stolen object or its parts: proper documentation of the object to facilitate identification by the police.

[link to references]

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[8] For the unlikely case that risk reduction recommendations for one material happen to be conflicting with those for another material, an internal set of criteria can be built in the database to select the most appropriate recommendations for the object as a whole. For instance, if the object has metal that is particularly sensitive to corrosion requiring the lowest RH possible, and hygroscopic materials that require a RH in the 'mid-range' (i.e., lower RHs would be damaging), than the database will not output in the final overview a recommendation to store/keep the object 'in the lowest RH possible'. There will be a cut-off value for the 'low RH' recommendation corresponding to the 'mid-range' values required by the hygroscopic materials that co-exist in the same object.

Pollutants: faster silver tarnishing caused by sulphur-based gases emitted by wool (silver-wool-enclosed).
Incorrect RH: faster silver tarnishing caused by high RH (damp). Note: if the enclosed space containing the material is airtight, this risk of incorrect RH is usually less significant.

[link to illustrated examples]

• Avoid conditions of high relative humidity (damp) that promote the corrosion of metals; keep the silver surface free of dust and grime.
• Block harmful gases and water vapour: if impossible to avoid high RH conditions in the room, display the object in an airtight case or store it inside a moisture-tight bag or container where the RH can be more easily controlled (using desiccants if necessary); apply a suitable protective coating on the silver surface.
• Detect: monitor RH levels in the room and inside the display unit or storage container; monitor the appearance and rate of silver tarnishing in the object.
• Respond: review and adjust 'Avoid' and 'Block' measures as necessary if significant deviations from their intended effect are detected.
• Recover: properly remove tarnish from affected surfaces if deemed necessary (this should not be done frequently, as each time a certain amount of underlying silver is removed along with the surface layer of tarnish).

[link to references]

Physical forces: abrasion of surfaces and possible breakage of parts of silver elements due to excessive handling of the object. Note: because the silver elements are enclosed in a compartment, this risk less significant.

[link to illustrated examples]

• Avoid handling the object unnecessarily; train and equip staff to do it correctly.
• Block damaging forces: protect the object with suitable (wrapping) materials when handling it.
• Detect incorrect handling : monitor the object closely while it is being handled.
• Respond to incorrect handling: instruct handlers to adjust faulty procedures if detected.
• Recover: conserve-restore the affected silver elements if they reach an unacceptable level of mechanical deterioration.

[link to references]

Pollutants: loss of shine and possible abrasion of silver elements because of dust deposition and encrustation. Note: if the compartment containing the material is airtight, the risk is less significant.

[link to illustrated examples]

• Avoid keeping the object in a dusty environment; avoid activities that generate dust in the area where the object is kept (e.g., construction and renovation works, inadequate dusting procedures).
• Block: install effective dust barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor the condition of the material over time; monitor the levels of dust inside the storage/display unit and room.
• Respond: properly remove dust from the storage/display unit and room if detected levels are unacceptable.
• Recover: properly remove the dust from the material if detected levels are unacceptable.

[link to references]

II. COPPER

Criminals: theft of the object or its copper elements. [link to illustrated examples]

• Avoid conditions that facilitate theft: object unattended and/or easily within reach; visitors carrying bags or other belongings where small objects or their parts can be easily concealed.
• Block the access of thieves: effective barriers at the building, room, and storage/display unit levels.
• Detect the presence of thieves or attempted thefts: alarm, CCTV, security guards.
• Respond to theft attempts: clear response procedures; well-trained staff.
• Recover stolen object or its parts: proper documentation of the object to facilitate identification by the police.

[link to references]

Physical forces: abrasion of surfaces and possible breakage of parts of copper elements due to excessive handling of the object. Note: because the copper elements are inlayed, the risk of breakage should be less significant than that of damage by abrasion.

[link to illustrated examples]

• Avoid handling the object unnecessarily; train and equip staff to do it correctly.
• Block damaging forces: protect the object with suitable (wrapping) materials when handling it.
• Detect incorrect handling : monitor the object closely while it is being handled.
• Respond to incorrect handling: instruct handlers to adjust faulty procedures if detected.
• Recover: conserve-restore the affected copper elements if they reach an unacceptable level of mechanical deterioration.

[link to references]

Pollutants: faster (additional) copper corrosion caused by volatile organic acids emitted by wood (wood-copper-inlay).
Incorrect RH: faster (additional) copper corrosion caused by high RH (damp).
Note: if the copper elements are already covered with a stable patina layer, the risk of further corrosion is typically less significant.

[link to illustrated examples]

• Avoid conditions of high relative humidity (damp) that promote the corrosion of metals; keep the copper surface free of dust and grime.
• Block harmful gases and water vapour: if impossible to avoid high RH conditions in the room, display the object in an airtight case or store it inside a moisture-tight bag or container where the RH can be more easily controlled (using desiccants if necessary); apply a suitable protective coating on the copper surface.
• Detect: monitor RH levels in the room and inside the display unit or storage container; monitor the appearance and rate of copper corrosion in the object.
• Respond: review and adjust ‘Avoid’ and ‘Block’ measures as necessary if significant deviations from their intended effect are detected.
• Recover: properly remove unstable corrosion products from affected surfaces if present.

[link to references]

Pollutants: (additional) aesthetical loss and possible abrasion of copper surfaces because of dust deposition and encrustation.

[link to illustrated examples]

• Avoid keeping the object in a dusty environment; avoid activities that generate dust in the area where the object is kept (e.g., construction and renovation works, inadequate dusting procedures).
• Block: install effective dust barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor the condition of the material over time; monitor the levels of dust inside the storage/display unit and room.
• Respond: properly remove dust from the storage/display unit and room if detected levels are unacceptable.
• Recover: properly remove the dust from the material if detected levels are unacceptable.

[link to references]

III. WOOL

Light/UV: additional colour fading (if dyed), yellowing and weakening.

[link to illustrated examples]

• Avoid unnecessary exposure: no direct sunlight; if stored, keep the storage area in the dark as much as possible; if on display, avoid light sources with high UV output, avoid unnecessarily high light levels on the object and long display times.
• Block or attenuate the incidence of light and UV: effective light and UV barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor light and UV levels close to the surface of the material; monitor the condition of the material over time. If the wool is dyed, evaluate the degree of colour fading expected in the future by using CCI´s light damage calculator.
• Respond: review and adjust ‘Avoid’ and ‘Block’ measures as necessary if significant deviations from their intended effect are detected.
• Recover: conserve-restore the light/UV damaged wool if it reaches an unacceptable level of deterioration.

[link to references]

Pests: (additional) damage by insects that feed on wool (e.g. clothes moths and dermestids).
Note: if the compartment containing the material is sealed, the risk is less significant.

[link to illustrated examples]

• Avoid conditions that support pests in the object’s storage or display surroundings (sources of food and moisture; clutter); avoid introducing objects that could possibly be infested.
• Block the access of pests: effective barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor the condition of the material over time; monitor the storage/display unit, room, and building for the presence of pests.
• Respond: if infestation is detected on the material, segregate the object immediately by sealing it in a container or bag; apply a suitable treatment to exterminate the pests (e.g., fumigation with carbon dioxide or nitrogen, oxygen scavengers, etc.). If infestation is detected on nearby objects, respond likewise.
• Recover: conserve-restore the insect damaged wool if the level of deterioration is unacceptable.

[link to references]

Physical forces: breakage and loss of fragments if the wool is too brittle, due to excessive handling of the object. Note: because the wool is enclosed in a compartment, the risk of damage by direct contact with the material is less significant. Damage by vibration and shock is more likely.

[link to illustrated examples]

- Avoid handling the object unnecessarily; train and equip staff to do it correctly.
- Block damaging forces: protect the object with suitable (wrapping) materials when handling it.
- Detect incorrect handling : monitor the object closely while it is being handled.
- Respond to incorrect handling: instruct handlers to adjust faulty procedures if detected.
- Recover: conserve-restore the affected woolen elements if they reach an unacceptable level of mechanical deterioration.

[link to references]

Incorrect RH: mould growth promoted by high RH. Note: if the enclosed space containing the material is airtight, this risk is usually less significant.

[link to illustrated examples]

- Avoid conditions of high relative humidity (damp) that promote mould growth on wool.
- Block moisture: if impossible to avoid high RH conditions in the room, display or store the object inside a moisture-tight case or container where the RH can be more easily controlled (using desiccants if necessary).
- Detect: monitor RH levels in the room and inside the display unit or storage container; monitor the material for the appearance and growth of mould.
- Respond: review and adjust 'Avoid' and 'Block' measures for incorrect RH as necessary if mould starts to grow on the material because of high RH (consider the use of portable dehumidifiers in the room if necessary).
- Recover: properly remove the mould from the material.

[link to references]

Pollutants: (additional) aesthetic loss because of dust deposition. Note: if the compartment containing the material is airtight, the risk is less significant.

[link to illustrated examples]

- Avoid keeping the object in a dusty environment; avoid activities that generate dust in the area where the object is kept (e.g., construction and renovation works, inadequate dusting procedures).
- Block: install effective dust barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
- Detect: monitor the condition of the material over time; monitor the levels of dust inside the storage/display unit and room.
- Respond: properly remove dust from the storage/display unit and room if detected levels are unacceptable.
- Recover: properly remove the dust from the material if detected levels are unacceptable.

[link to references]

IV. WOOD

Pests: damage by insects that feed on wood (e.g. termites and anobiids).

[link to illustrated examples]

- Avoid conditions that support pests in the object's storage or display surroundings (sources of food and moisture; clutter); avoid introducing objects that could possibly be infested.
- Block the access of pests: effective barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
- Detect: monitor the condition of the material over time; monitor the storage/display unit, room, and building for the presence of pests.
- Respond: if infestation is detected on the material, segregate the object immediately by sealing it in a container or bag; apply a suitable treatment to exterminate the pests (e.g., fumigation with carbon dioxide or nitrogen, oxygen scavengers, etc.). If infestation is detected on nearby objects, respond likewise.
- Recover: conserve-restore the insect damaged wood if the level of deterioration is unacceptable.

[link to references]

Incorrect RH: mould growth and possible rotting of wood promoted by high RH.

[link to illustrated examples]

- Avoid conditions of high relative humidity (damp) that promote mould growth on wood. Eliminate sources of moisture.
- Block moisture: if impossible to avoid high RH conditions in the room, display or store the object inside a moisture-tight case or container where the RH can be more easily controlled (using desiccants if necessary).
- Detect: monitor RH levels in the room and inside the display unit or storage container; monitor the material for the appearance and growth of mould.
- Respond: review and adjust 'Avoid' and 'Block' measures for incorrect RH as necessary if mould starts to grow on the material because of high RH (consider the use of portable dehumidifiers in the room if necessary).
- Recover: properly remove the mould from the material.

[link to references]

Physical forces: abrasion and chipping of wooden parts due to excessive handling of the object.

[link to illustrated examples]

- Avoid handling the object unnecessarily; train and equip staff to do it correctly.
- Block damaging forces: protect the object with suitable (wrapping) materials when handling it.
- Detect incorrect handling : monitor the object closely while it is being handled.
- Respond to incorrect handling: instruct handlers to adjust faulty procedures if detected.
- Recover: conserve-restore the affected wooden elements if they reach an unacceptable level of mechanical deterioration.

[link to references]

Light/UV: greying and surface erosion of wooden parts by UV. Note: if the UV levels in the environment are significantly lower than that of full daylight through window glass, the risk is less significant.

[link to illustrated examples]

• Avoid unnecessary exposure: no direct sunlight; avoid prolonged exposure to full daylight and other intense light sources with high UV output.
• Block or attenuate the incidence of high levels of light and UV: effective light and UV barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor light and UV levels close to the surface of the material; monitor the condition of the material over time.
• Respond: review and adjust 'Avoid' and 'Block' measures as necessary if significant deviations from their intended effect are detected.
• Recover: conserve-restore the UV damaged wooden elements if they reach an unacceptable level of deterioration.

[link to references]

Pollutants: aesthetic loss because of dust deposition and encrustation on wooden elements.

[link to illustrated examples]

• Avoid keeping the object in a dusty environment; avoid activities that generate dust in the area where the object is kept (e.g., construction and renovation works, inadequate dusting procedures).
• Block: install effective dust barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor the condition of the material over time; monitor the levels of dust inside the storage/display unit and room.
• Respond: properly remove dust from the storage/display unit and room if detected levels are unacceptable.
• Recover: properly remove the dust from the material if detected levels are unacceptable.

[link to references]

V. GLASS

Physical forces: accidental breakage/cracking of glass during handling of the object.

[link to illustrated examples]

• Avoid handling the object unnecessarily; train and equip staff to do it correctly.
• Block damaging forces: protect the object with suitable (wrapping) materials when handling it.
• Detect incorrect handling : monitor the object closely while it is being handled.
• Respond to incorrect handling: instruct handlers to adjust faulty procedures if detected.
• Recover: conserve-restore the broken/cracked glass if deemed necessary.

[link to references]

Pollutants: aesthetic or transparency loss because of dust deposition and encrustation.

[link to illustrated examples]

• Avoid keeping the object in a dusty environment; avoid activities that generate dust in the area where the object is kept (e.g., construction and renovation works, inadequate dusting procedures).
• Block: install effective dust barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
• Detect: monitor the condition of the material over time; monitor the levels of dust inside the storage/display unit and room.
• Respond: properly remove dust from the storage/display unit and room if detected levels are unacceptable.
• Recover: properly remove the dust from the material if detected levels are unacceptable.

[link to references]

SUMMARY OF RISKS AND RECOMMENDATIONS

Criminals: theft of the object or its parts.

• Avoid conditions that facilitate theft: object unattended and/or easily within reach; visitors carrying bags or other belongings where small objects or their parts can be easily concealed.
• Block the access of thieves: effective barriers at the building, room, and storage/display unit levels.
• Detect the presence of thieves or attempted thefts: alarm, CCTV, security guards.
• Respond to theft attempts: clear response procedures; well-trained staff.
• Recover stolen object or its parts: proper documentation of the object to facilitate identification by the police.

Incorrect RH: faster corrosion of metals and mould growth on susceptible materials promoted by high RH. Note: materials that are enclosed in airtight compartments are typically less prone to this type of damage.

• Avoid conditions of high relative humidity (damp) that promote corrosion and mould growth. Eliminate sources of moisture.
• Block moisture: if impossible to avoid high RH conditions in the room, display or store the object inside a moisture-tight case or container where the RH can be more easily controlled (using desiccants if necessary); apply a suitable protective coating on the metallic surfaces.
• Detect: monitor RH levels in the room and inside the display unit or storage container; monitor the material for the appearance and rates of corrosion and mould growth.
• Respond: review and adjust 'Avoid' and 'Block' measures for incorrect RH as necessary if metals start to corrode or mould starts to grow on materials because of high RH (consider the use of portable dehumidifiers in the room if necessary).
• Recover: properly conserve-restore the elements affected by corrosion and mould if deemed necessary.

Physical forces: mechanical damage due to excessive handling of the object.

• Avoid handling the object unnecessarily; train and equip staff to do it correctly.
• Block damaging forces: protect the object with suitable (wrapping) materials when handling it.
• Detect incorrect handling : monitor the object closely while it is being handled.
• Respond to incorrect handling: instruct handlers to adjust faulty procedures if detected.
• Recover: conserve-restore the affected parts if they reach an unacceptable level of mechanical deterioration.

Pollutants: deterioration of materials caused by harmful chemicals released by other materials they are enclosed together or in direct contact with.

- Avoid buildup of harmful volatile compounds inside enclosures or at the interface between reactive materials that are in direct contact with each other by increasing ventilation (if possible); introduce suitable adsorbents to remove harmful volatile compounds inside enclosures or at the interface between reactive materials that are in direct contact with each other (if possible).
- Block harmful compounds by applying a suitable coating on sensitive surfaces or introducing a compatible protective layer between reactive materials (if possible).
- Detect: monitor the appearance and rate of deterioration of susceptible materials in the object.
- Respond: review and adjust 'Avoid' and 'Block' measures as necessary if significant deviations from their intended effect are detected.
- Recover: properly conserve-restore damaged materials if deemed necessary.

Light/UV: (additional) fading of colours, discolouration, weakening and erosion of sensitive materials.

- Avoid unnecessary exposure: no direct sunlight; if stored, keep the storage area in the dark as much as possible; if on display, avoid light sources with high UV output, avoid unnecessarily high light levels on the object and long display times.
- Block or attenuate the incidence of light and UV: effective light and UV barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
- Detect: monitor light and UV levels close to the surface of the object; monitor the condition of light/UV-sensitive materials over time. Evaluate the degree of colour fading expected in the future by using CCI´s light damage calculator.
- Respond: review and adjust 'Avoid' and 'Block' measures as necessary if significant deviations from their intended effect are detected.
- Recover: conserve-restore the light/UV damaged materials if they reach an unacceptable level of deterioration.

Pests: (additional) damage of sensitive materials caused by pest attack (insects, rodents)

- Avoid conditions that support pests in the object's storage or display surroundings (sources of food and moisture; clutter); avoid introducing objects that could possibly be infested.
- Block the access of pests: effective barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
- Detect: monitor the condition of the object over time; monitor the storage/display unit, room, and building for the presence of pests.
- Respond: if infestation is detected on the object, segregate it immediately by sealing in a container or bag; apply a suitable treatment to exterminate the pests (e.g., fumigation with carbon dioxide or nitrogen, oxygen scavengers, etc.). If infestation is detected on nearby objects, respond likewise.
- Recover: conserve-restore the pest damaged materials if the level of deterioration is unacceptable.

Pollutants: aesthetic losses and possible abrasion of sensitive surfaces caused by dust deposition and encrustation on the object.

- Avoid keeping the object in a dusty environment; avoid activities that generate dust in the area where the object is kept (e.g., construction and renovation works, inadequate dusting procedures).
- Block: install effective dust barriers wherever appropriate at the room, storage/display unit, and/or packaging level.
- Detect: monitor the condition of the object over time; monitor the levels of dust inside the storage/display unit and room.
- Respond: properly remove dust from the storage/display unit and room if detected levels are unacceptable.
- Recover: properly remove the dust from the object if detected levels are unacceptable.

Ensure that all risk reduction measures already in place are properly maintained.

In this example, the decision matrix shown below has been used to rank order the different 'risk warnings' and corresponding recommendations for the object as a whole. Each material present in the object has been given a weight to indicate its relative significance, following a 2^k geometric progression - starting with '1' (2^0) until 2^{m-1} (where *m* is the number of materials present in the object, in this case *m*=5). This means that a factor of *2x* has been arbitrarily chosen to indicate the difference in significance between two consecutive materials in the list inputted by the user. For each material, the corresponding material-specific risks were given a similar score to indicate their level of relevance, starting in decreasing order from 2^{r-1} until 2^{r-s} (where *r* is the maximum number of material-specific 'risk warnings' outputted among all materials, in this case *r*=5, and *s* is the number of such warnings for the material being considered)[9]. Likewise, this means that a factor of *2x* has been arbitrarily chosen to quantify the difference between two consecutive material-specific risks outputted by the database for each material present in the object. This arbitrary quantification of differences in relative significance of materials, and among material-specific risks, serves solely the practical purpose of facilitating the rank ordering of 'risk warnings' and recommendations for the object as a whole. Obviously, alternative ways/criteria to do so can be discussed and adopted by the project partners as the tool is being developed.

Relative significance of materials in the object

1	2	4	8	16	
Glass	**Wood**	**Wool**	**Copper**	**Silver**	Level of material-specific risks
Excessive handling	Pests	Light/UV	Theft	Theft	16
Dust	High RH	Pests	Excessive handling	High RH Cross - contamination	8
	Excessive handing	Excessive handling	High RH Cross-contamination	Excessive handling	4
	Light/UV	High RH	Dust	Dust	2
	Dust	Dust			1

[9] In this example, the maximum number of material-specific 'risk warnings' was *r*=5, outputted for the materials WOOL and WOOD. The values of *r* and *s* coincide for these two materials. The values of *s* for the other materials present in the object are: *s*=2 (GLASS), *s*=4 (COPPER), *s*=4 (SILVER).

Calculations to define the rank-order of risks and corresponding recommendations for the object as a whole, based on the decision matrix shown above:

Theft: (16x16) + (8x16) = 384	Rank order: 1
RH too high: (16x8) + (8x4) + (4x2) + (2x8) = 184	Rank order: 2
Excessive handling: (16x4) + (8x8) + (4x4) + (2x4) + (1x16) = 168	Rank order: 3
Cross-contamination: (16x8) + (8x4) = 160	Rank order: 4
Light/UV: (4x16) + (2x2) = 68	Rank order: 5
Pests: (4x8) + (2x16) = 64	Rank order: 6
Dust: (16x2) + (8x2) + (4x1) + (2x1) + (1x8) = 62	Rank order: 7

As mentioned before, the sums of products obtained through these calculations do not reflect the actual differences in the size of risks to the object. They are only a possible, simplified and approximative way to programme the database to rank order these risks in the summary output to users.

A user-friendly interface will be designed and validated to optimize the usability of outputs for the target users of the *Decision Support Tool*.

Annex 2 : Functioning of AGATO by Multimedium, web developer (Risk Selection & Risk Ranking), 2022

Risks to an object

AGATO assembles the risk assessment for a mixed media object in **two phases**:

- **Risk Selection**
- **Risk Ranking**

This document elaborates on each phase of the assessment process.

Risk Selection

First, AGATO selects the risks that might apply to the mixed media object. It does so by matching properties of Risks, to properties in the mixed media object. For example, a Risk defined for a specific 1) **material**, will appear in the selection if this material is also present in the object. The same goes for matches on 2) **Material Combinations**, 3) **Environmental Hazards**, and 4) **Conditions**.

> Side note: The **Agents shown for each risk**, are not directly linked to the Risk. They are linked to Environmental Hazards though, and are therefore derived from these Hazards. Agents are displayed as an extra piece of information, and for the user's convenience. They are however not involved in the process of selecting the Risks being displayed.

A Risk can target few properties, or many

A Risk can be defined with these 4 properties. By selecting values for these properties, a Risk is "targeted" at objects that match these properties. However, that does not necessarily mean that the Risk will define values for all 4 of these properties.

For example, it is perfectly possible that a Risk is defined only for one (or more) Environmental Hazard(s). That would mean that it only holds a value for one of the properties. In that case, as the Risk carries less values, it is made less specific and it will probably apply to (or match with) more objects.

All properties must match

By adding materials, material combinations, environmental hazards and conditions to a Risk, you make it more specific. The Risk will be selected only if ***all* of these properties are matched** in the object. Consider an example where a Risk would be defined for the material "**Brass**", the Environmental Hazard "**Pollution**", the condition "**Fair**" and "**Poor**". This Risk would only be selected for objects...

- ... that have listed "Brass" as one of the materials,
- ... for which the question(s) related to the Environmental Hazard "Pollution" were answered with "Yes", and
- .... that indicated the condition of the material as either "Fair" or "Poor".

An object with the same materials and environmental hazards, but where the condition of the material would be unspecified or "Good", would **not match** that same Risk. Hence, **all** properties must be matched.

NOTE: When selecting Risks, AGATO will also match on **combinations** of materials that are present in the object (and in applicable Risks). AGATO will then attempt to match on the type of contact, too. Unless this type is indicated as "**Unspecified**". In that case, the **type of contact** is not taken into account, when matching material combinations in the object, to combinations in the Risks.

The selection of Risks does not take into account **the order** in which Risks should be presented to the end-user of AGATO. This order of presentation is important though, as it indicates the **importance** of Risks. That order is established in the next step, by the process of **Risk Ranking**.

Match on all properties, any value

As we have established, all of the Risk properties (with values) need to match. However, it is possible that one single property in the Risk carries more than one value. For example, a Risk can be targeted at objects with conditions "**Fair**" and "**Poor**" at the same time. In that case, both objects with the condition "Fair" and objects with the condition "Poor" will be matched to this Risk. In other words, while we need a match on **all properties**, a match is made as soon as **one of the values matches**. It is not a requirement to match all values in one single property.

This applies to all properties, and not only to the conditions (as mentioned in our example). The same principle goes for the values selected in the Risk for 1) Materials, 2) **Material Combinations**, 3) **Environmental Hazards**, and 4) **Conditions**.

Risk Ranking

The ranking of Risks is based on **three ideas**:

1. Risks that might apply to the **most significant** —or **prevalent**— materials, should get a higher score.
2. Risks that are **more specific** to the mixed media object, are considered very relevant and applicable to that object, and therefore should get a higher score.
3. Some environmental hazards have more impact on a certain material than others. This **vulnerability** of a material to being damaged through exposure to a hazard, should be taken into account by the ranking.

In order to achieve a Ranking that takes these three fundamental ideas into account, the AGATO tool calculates a value for **three separate parameters**. We call them the "**M Score**", the "**P Score**" and the "**V Score**".

M Score

Obviously, an automated tool such as AGATO cannot really tell what materials are the most significant or prevalent in a mixed media object. AGATO therefore continues on the assumption that end-users will effectively **add materials in the order of significance (or prevalence)**. This is why AGATO allows for the end-user to arrange the order of materials 1) by prevalence and 2) by significance separately, should materials be interpreted differently in each scenario to his/her opinion.

In each scenario, by significance or by prevalence, the first material in the list will be considered the most important one. This material will get the highest value. The last material will get the lowest value though: the value 1. For example, consider a mixed media object that consists of three materials: 1) Enamel, 2) Brass and 3) Leather. If defined in that order, **by significance**, the materials will get the following values:

- Enamel — **3**
- Brass — **2**
- Leather — **1**

Note that the end-user can change the order of materials in the object, for the other scenario. In this case, the end-user could decide to **rearrange** this order when considering the materials in the object **by prevalence**. Let's assume the end-user rearranges the materials in the order of 1) Leather, 2) Brass and 3) Enamel. Then the values will be like so, in that specific scenario:

- Leather — **3**
- Brass — **2**
- Enamel — **1**

Each Risk is possibly defined for one specific material, a selection of materials, or a specific combination thereof. Materials encountered in the Risk will be matched to materials in the object. For each match that is found by AGATO, the corresponding value is added to the M Score. In other words, the M score for a Risk is the sum of all addendums. In this example the addendum is 3 for Leather, 2 for Brass and 1 for Enamel. The sum, or the M Score for the Risk, will therefore be 6.

The M Score will therefore be susceptible to the scenario that is selected by the end-user, in AGATO's interface. If looking at results **by significance or by prevalence**, **different** material **values** will be added to the M Score (see earlier) while calculating a ranking for the Risk. Because the order in which materials are arranged in each criteria might be different.

We have made an example in which we consider three materials. This number depends on the number of materials identified in the object though, by the user of AGATO. The user might just as well identify 10 materials, in which case the addendums that contribute to the Risk's M Score (sum) will become 10, 9, 8, 7, 6, 5, 4, 3, 2 and 1. The user can define any number of materials, as long as each material is known by AGATO, and is therefore not limited in any way.

P Score

In the algorithm, the P Score addresses the concern of determining the Risks that are *more* specific to the mixed media object. More specific risks are considered more relevant/applicable to the object.

A Risk can be targeted at a selection of materials in the object, but can also be targeted at other parameters:

- **Material Combinations** — Does the object have a (predefined) combination of materials? We look at the materials involved, how these materials are combined, and the type of contact that materials make. Each predefined combination we can find both in the Risk and in the Object, is considered a match.

- **Conditions** — Does the object have materials in a specific condition, also targeted by the Risk? Each condition that is encountered both in the Risk and in the Object, is considered a match. Conditions derived from material combinations, will also be taken into account.
- **Environmental Hazards** — Did the end-user reply with "Yes" to questions about Environmental Hazards, for the object? Each question that was replied to with "Yes", also targeted by the Risk, is considered a match.

Each match will eventually **increment the P Score by 1**. This means that a higher number of matches, making a Risk more specific to the object, renders a higher value for the P Score.

V Score

The V Score aims at creating an extra factor in the algorithm, making the ranking of risks sensitive to specific **vulnerabilities** in the object.

The editors of AGATO can define Vulnerabilities by adding **modifier values** to the system. Each modifier value will be defined for an **Agent of Deterioration,** or an **Environmental Hazard**. In addition to that, the value can be defined specifically for a **material**, too. For example, an editor might choose to add the value **3**, for the Environmental Hazard "**Theft of parts of the object**" and the material **Silver**.

Note that, for now, the convention for modifier values is a **scale from 1** (lowest vulnerability) **to 3** (highest vulnerability). Decimal values are allowed in this scale. That means that the editor would be adding a **High Vulnerability** in the example described for the "**Theft of parts of the object**" and the material **Silver**. Administrators of AGATO have the ability to change this scale, and for example use a higher maximum. This means that the scale could be subject to change, in the future, if administrators consider this to be beneficial to the results.

AGATO will **repeat** the following logic, for each material encountered in the Risk (as well in the object):

- … **Run** through all of the **Environmental Hazards** defined for that Risk as well as for the object. Each iteration will then provide a unique combination of Material and Environmental Hazards, allowing AGATO to look up a modifier value for that specific combination. If such a value is found, the V Score will be incremented by that value.
- … **Run** through all of the **Agents of Deterioration** defined for the Risk as well as for the object. Each iteration will then provide a unique combination of Material and Agent of

Deterioration, again allowing AGATO to look for a modifier value. Each value encountered, will again be added to the V Score.

Note that, with the modifier values, an editor of AGATO can also choose to **completely override the entire algorithm**, by choosing one of the following options (rather than defining a numerical value):

- **Push to top** — The Risk Ranking will be given the maximum value, and the Risk will be shown on top of the list in AGATO, **no matter what the calculated outcome** of the algorithm. This maximum value is 20. Why this maximum value is 20, is explained further down this document, in the chapter "Color coding".
- **Push to bottom** — Similar to "Push to top", pushing the Risk to the bottom of the list. The minimum value is 0, which is why "Push to bottom" Risks are normalized to the 0 (zero) value.

Vulnerabilities derived from material combinations

Elke Otten raised an issue, while fine-tuning the algorithm that establishes the V Score:

> *For example "Risk #11/50 - Brass - Leather" gets a V score of 0, in "Casket for the crown reliquary of Holy Thorns, Namur". This should actually never happen. In that case, we should use the materials found in the combination, in order to find more vulnerabilities. In this case, we should therefore scan for both the materials "Brass" and "Leather" individually.*

The algorithm was updated on March 4th, 2022, in order to comply with the above requirements. This means that, when establishing the V Score, AGATO will not only look at the individual materials, but will also include all the materials it can derive from material combinations.

Bringing scores together, in "Risk Ranking"

The final score is calculated by multiplying the M Score, the P Score and the V Score:

`(M Score) x (P Score) x (V Score)`

Note that any **score that is 0,** will be **left out of the algorithm**. This is done to avoid having the overall score reduced to zero, when one of the parameters did not collect values along the way.

Color Coding

All Risks in the AGATO assessment are given a ranking score by applying the algorithm as described. Obviously, the range of the resulting numbers can differ strongly from one object to the other, depending on the detail provided on the materials, the selection of conditions, the questionnaire on environmental hazards, the number of risks, and so on. Theoretically speaking, Risk Ranking scores could range from 1 to 100 or might as well range from 18 to 5000. This makes it hard for AGATO to apply color coding to Risks, indicating the severity of Risks.

AGATO will therefore **normalize the scores, on a scale of 0 to 20**. In order to achieve this, it will take the highest Risk Ranking score encountered, and bring it back to the maximum value of 20. The factor that is required to do this, will also be applied to all other Risk Ranking scores. The result of this operation is that all scores will rank from 0 to 20, making it possible for AGATO to apply color coding (predefined on the same scale).

Note: AGATO will automatically normalize to 20 for Risks that were modified with the value “Push to top”, or to 0 for Risks that were modified with “Push to bottom” (see chapter on “V Score”).

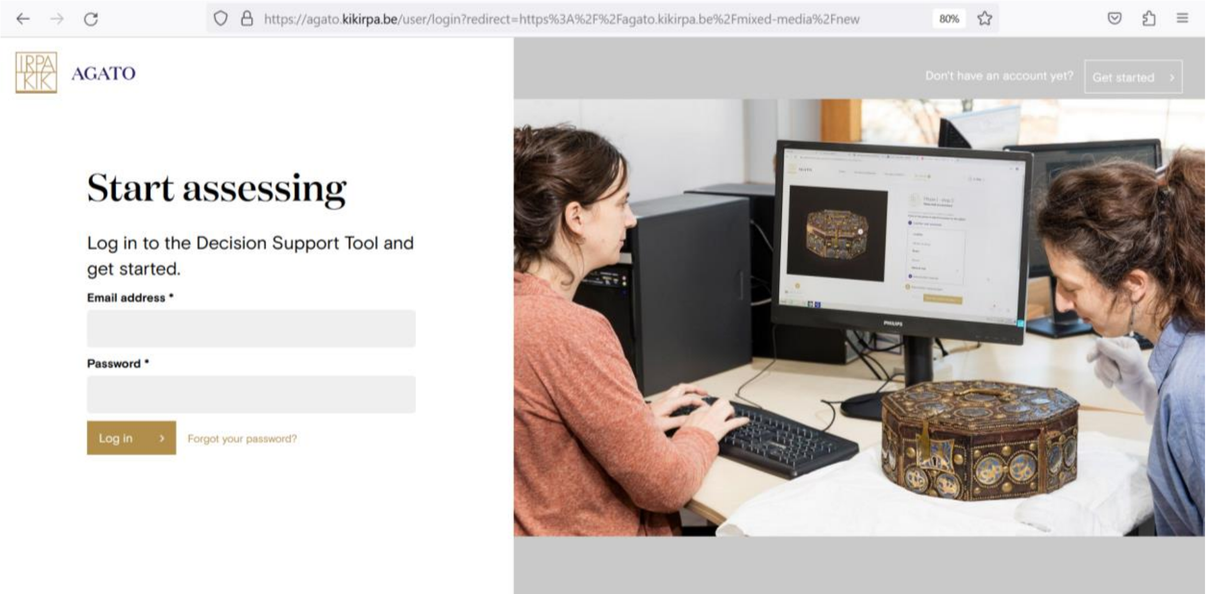
Annex 3 : Walk-through the AGATO process – user guidelines

Annex 6

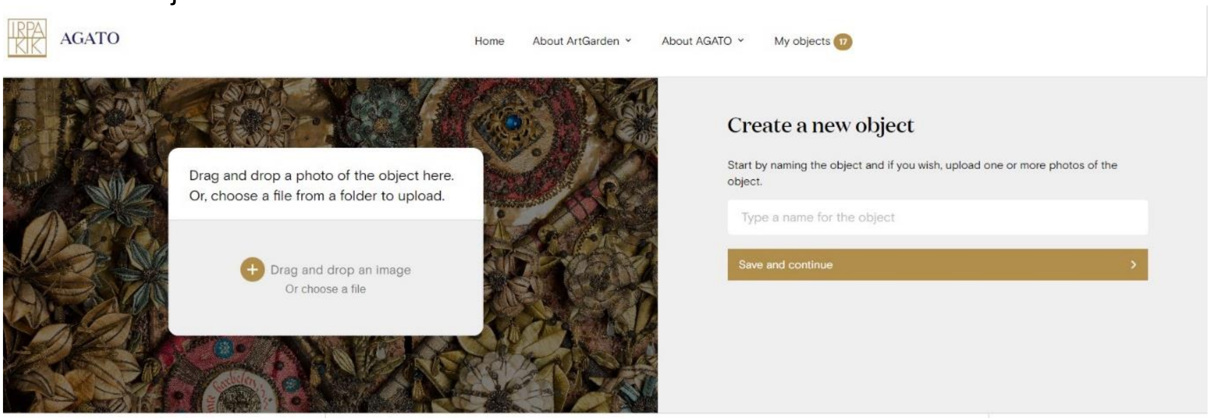
Walk-through the AGATO process : user guidelines

Input expected from the user:

- Make login (e-mail required, further information not mandatory)

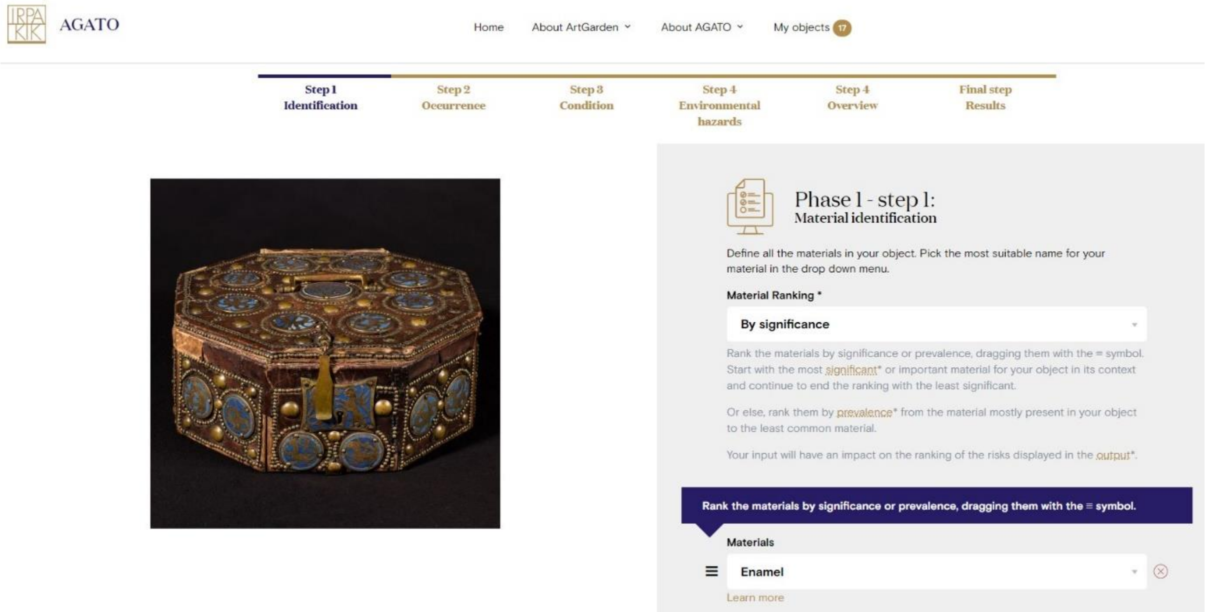


- Name the object to start an assessment

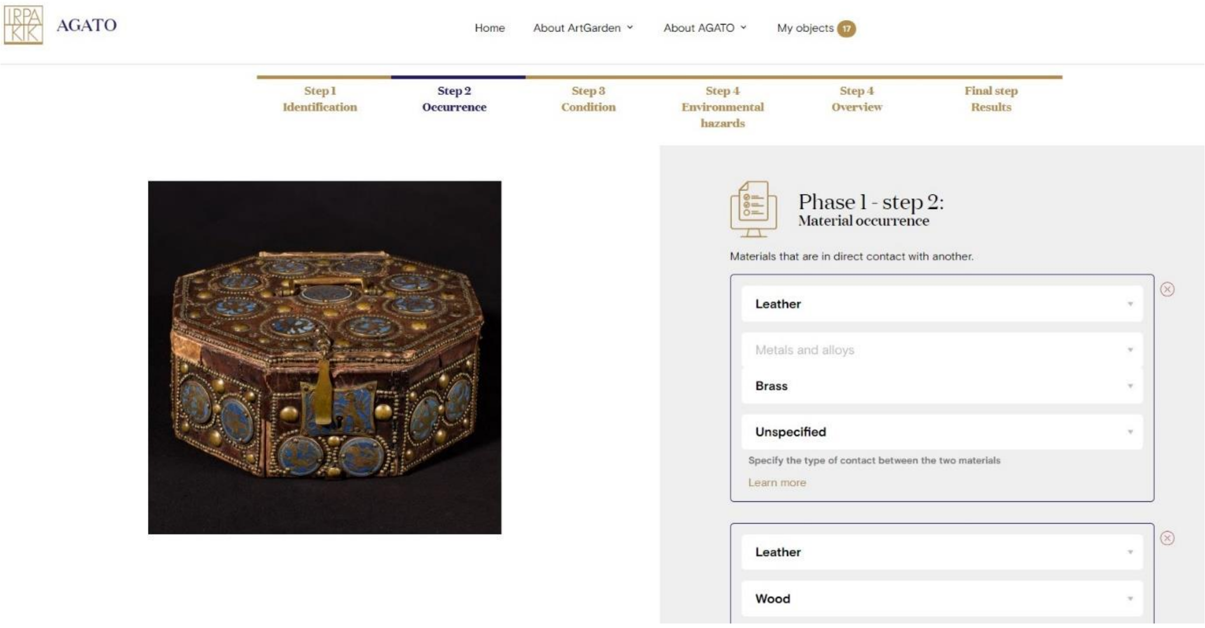


- Upload a photo (not mandatory)
- A progress bar displayed from the start of an assessment visually accompanies the fill-out process and allows to move back and forth

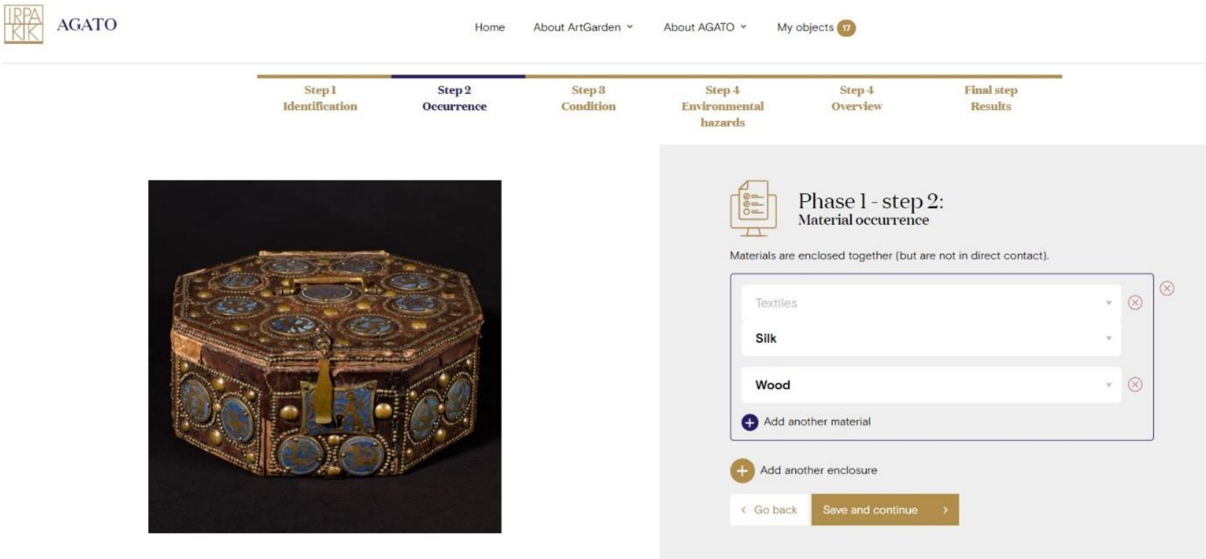
- Identify materials



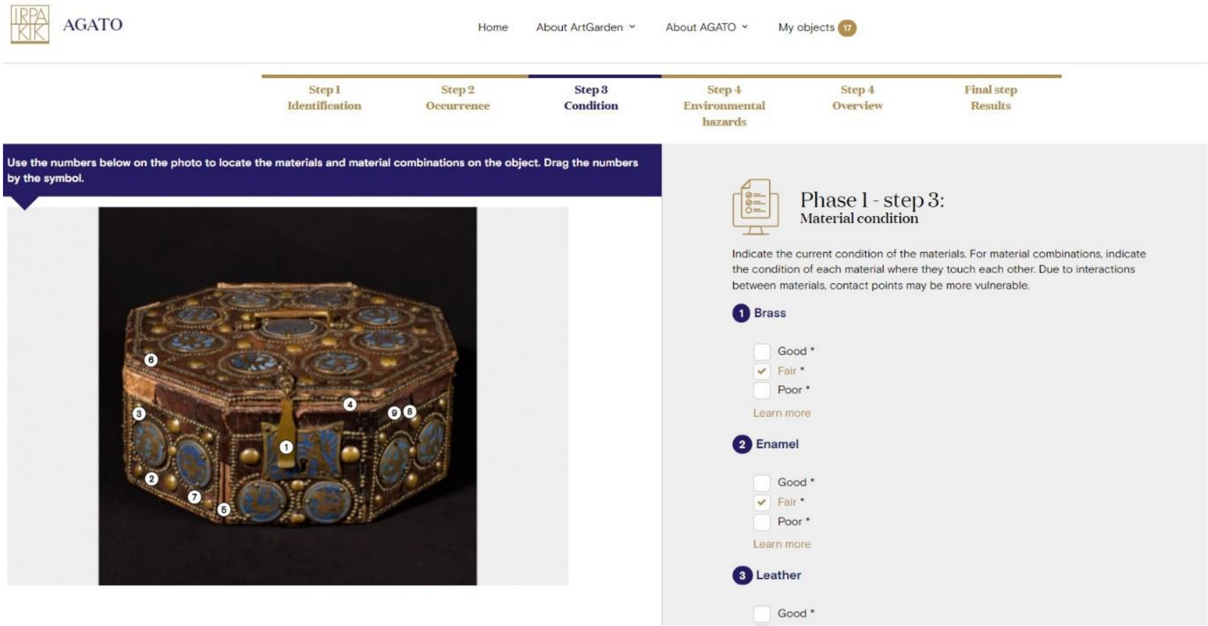
- Rank materials according to significance and / or prevalence
- Identify material combinations and the way they are combined (not mandatory)



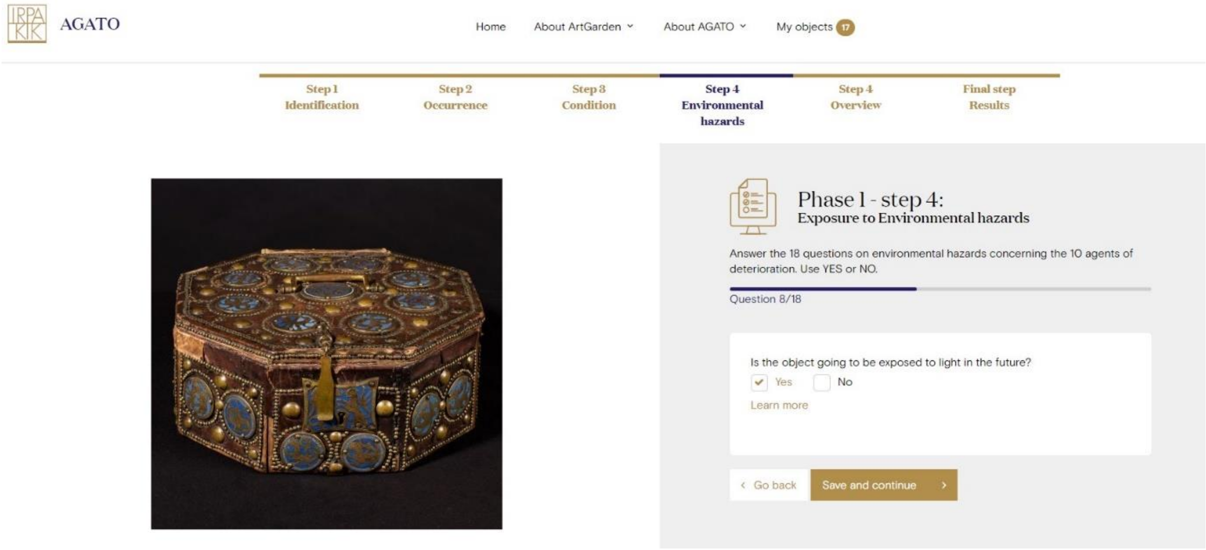
- Identify materials that are enclosed together (not mandatory)



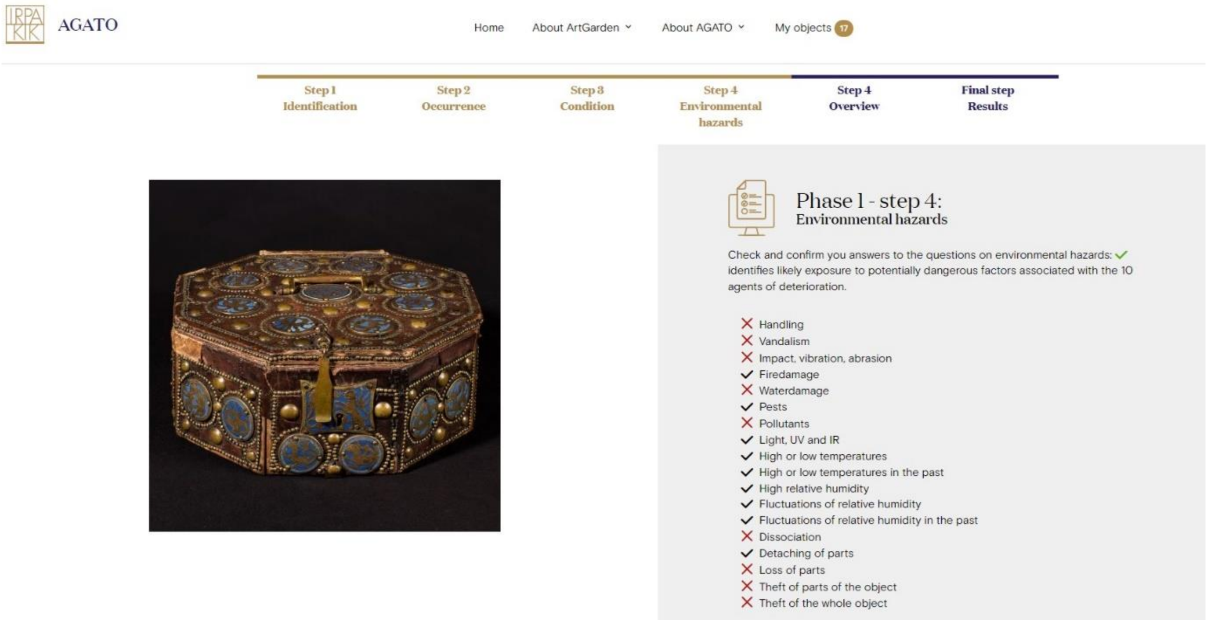
- Identify condition of each of the materials and of the materials directly touching another material. Number tags can indicate the locations on the picture. Extra pictures (for instance of details) may be added.



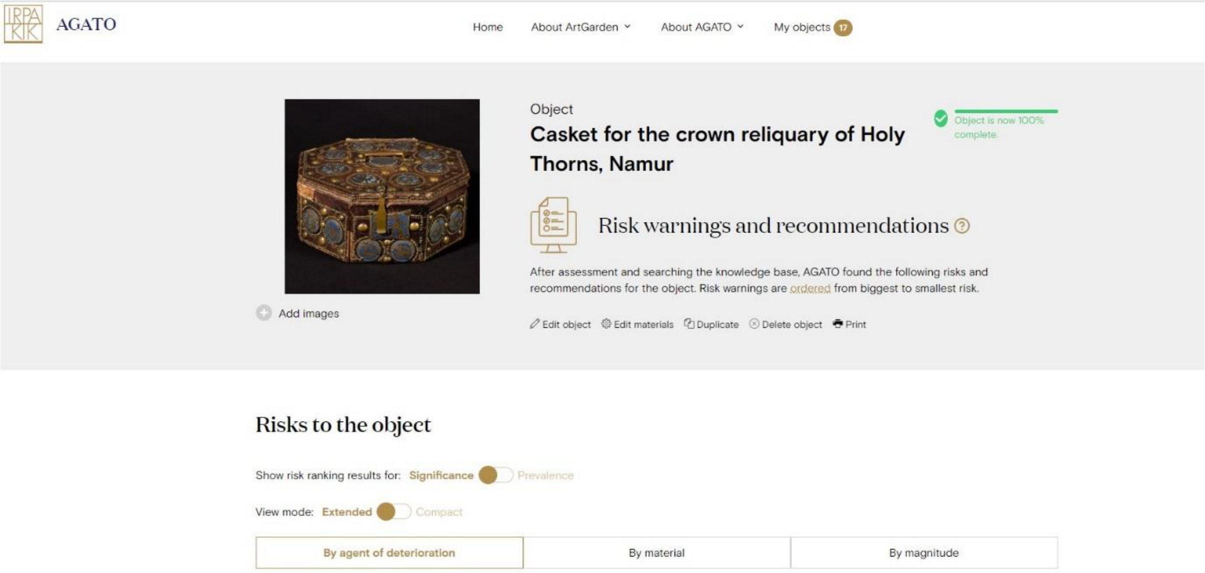
- Answer 18 questions about environmental hazards related to the 10 agenst of deterioration



- Check overview of answers

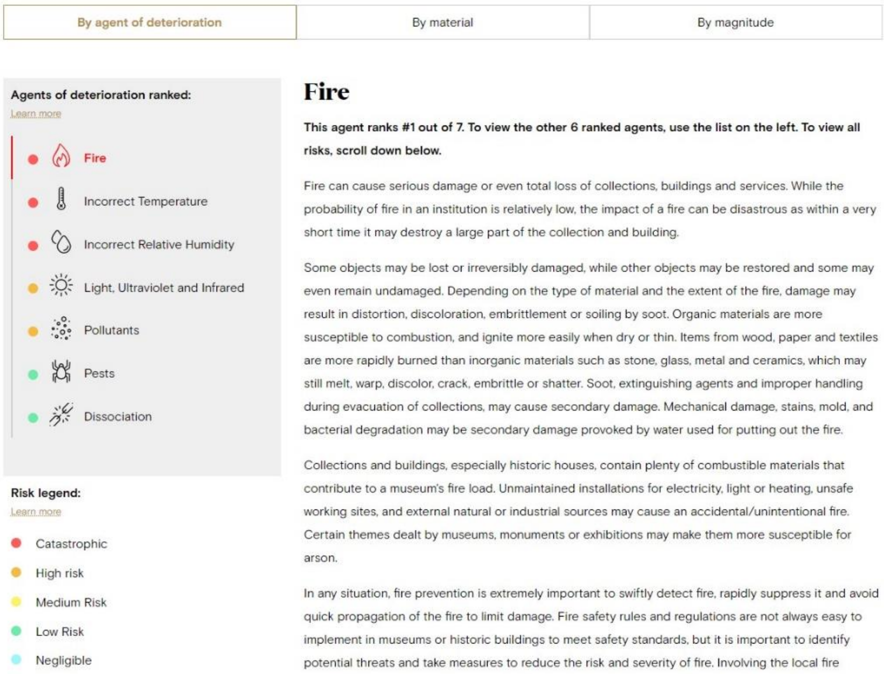


- View the results of the assessment

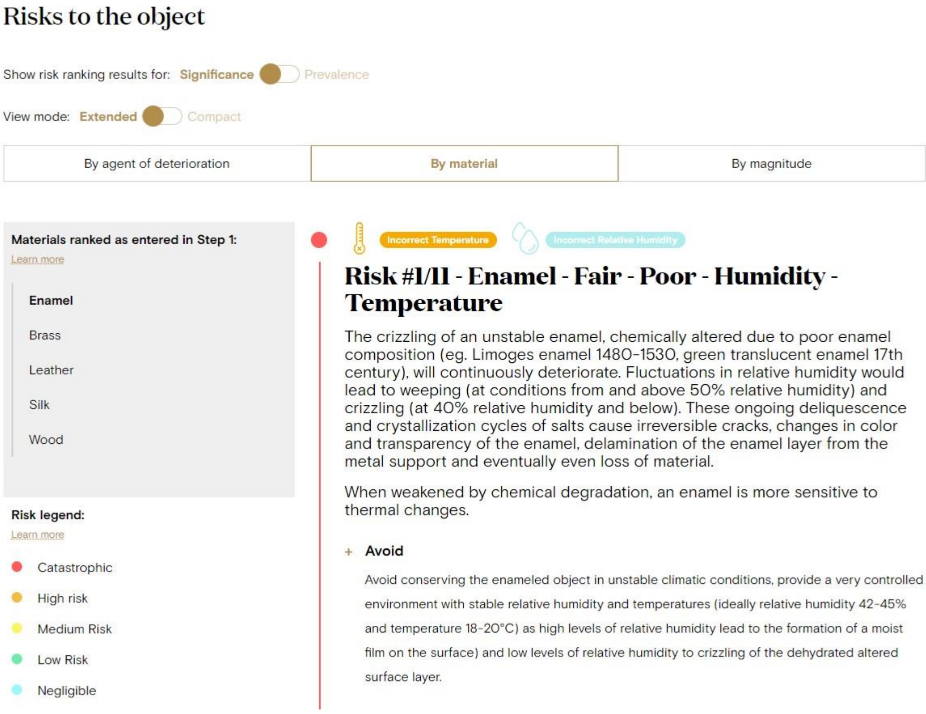


Results can be viewed in three ways:

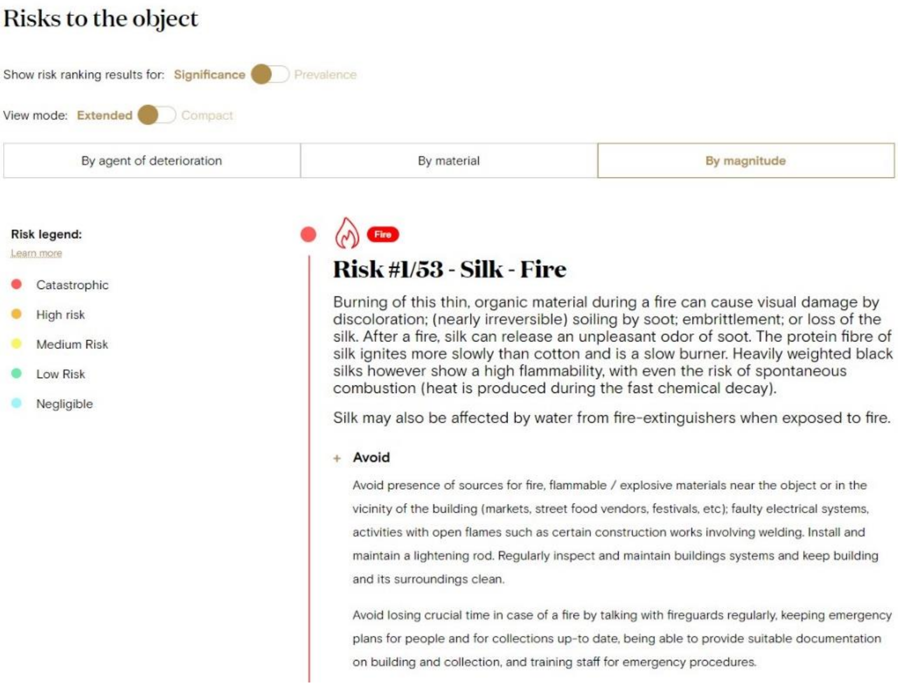
- First and overview of the agents of deterioration identified in the assessment, ranked by importance (visible by color scale). Clicking an agent in the list gives an overview of ranked risks specifically for that agent and general information about the agent.



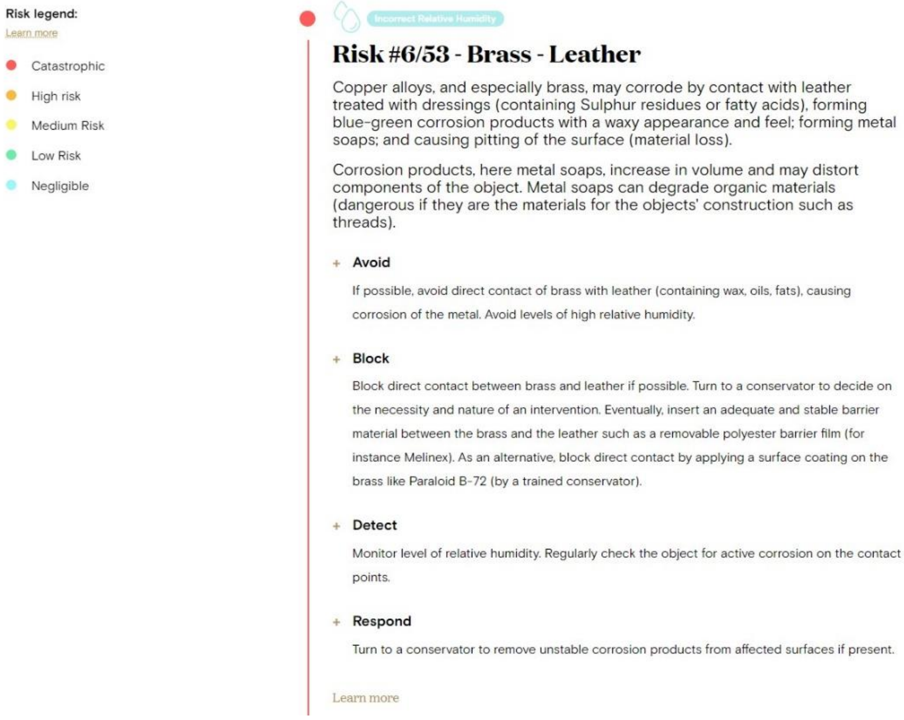
- Secondly, the materials present in the object are listed (as the user has ranked them). Clicking a material in the list gives an overview of ranked risks specifically for that material.



- Finally, all risks identified (for all materials and all agents present) are ranked according to the magnitude of the risks.



- Every risk describes the possible degradation of a material due to exposure to a certain agent of deterioration. Recommendations are given to avoid this degradation, to block the agent of deterioration to reach the material, to detect the presence of the agent and to respond in case the material was affected by the agent of deterioration. The same goes for material combinations.



Risk legend:

Learn more

- Catastrophic
- High risk
- Medium Risk
- Low Risk
- Negligible

Incorrect Relative Humidity

Risk #6/53 - Brass - Leather

Copper alloys, and especially brass, may corrode by contact with leather treated with dressings (containing Sulphur residues or fatty acids), forming blue-green corrosion products with a waxy appearance and feel; forming metal soaps; and causing pitting of the surface (material loss).

Corrosion products, here metal soaps, increase in volume and may distort components of the object. Metal soaps can degrade organic materials (dangerous if they are the materials for the objects' construction such as threads).

+ **Avoid**

If possible, avoid direct contact of brass with leather (containing wax, oils, fats), causing corrosion of the metal. Avoid levels of high relative humidity.

+ **Block**

Block direct contact between brass and leather if possible. Turn to a conservator to decide on the necessity and nature of an intervention. Eventually, insert an adequate and stable barrier material between the brass and the leather such as a removable polyester barrier film (for instance Melinex). As an alternative, block direct contact by applying a surface coating on the brass like Paraloid B-72 (by a trained conservator).

+ **Detect**

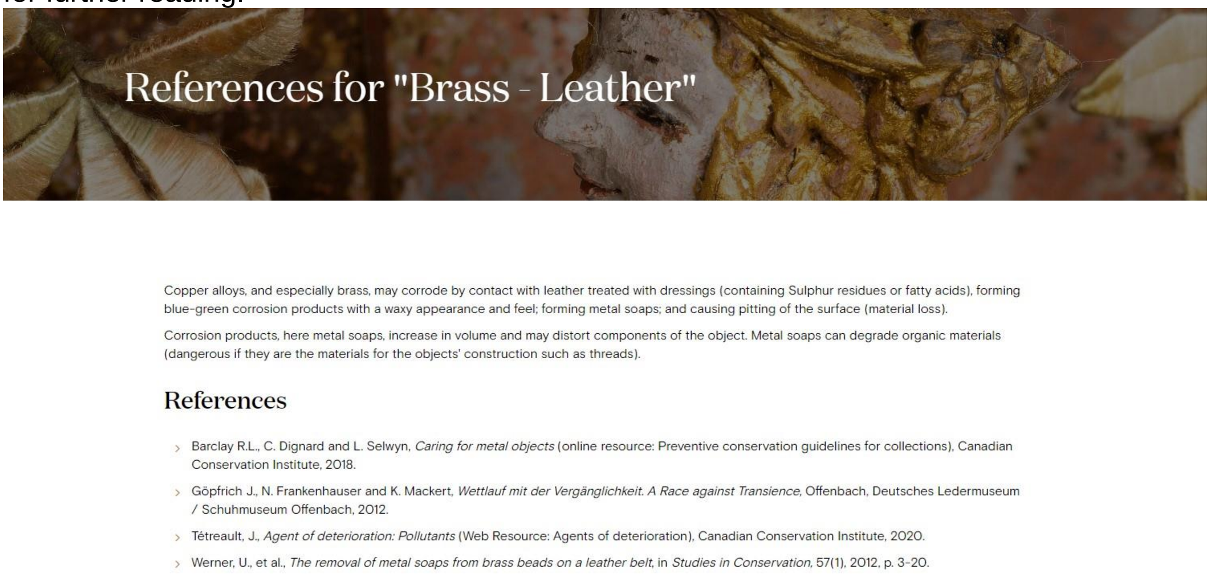
Monitor level of relative humidity. Regularly check the object for active corrosion on the contact points.

+ **Respond**

Turn to a conservator to remove unstable corrosion products from affected surfaces if present.

Learn more

- Every 'risk & recommendation' that is shown, mentions also 'learn more'. Clicking 'learn more' leads to the bibliographical references that are used and may be useful for further reading.



References for "Brass - Leather"

Copper alloys, and especially brass, may corrode by contact with leather treated with dressings (containing Sulphur residues or fatty acids), forming blue-green corrosion products with a waxy appearance and feel; forming metal soaps; and causing pitting of the surface (material loss).

Corrosion products, here metal soaps, increase in volume and may distort components of the object. Metal soaps can degrade organic materials (dangerous if they are the materials for the objects' construction such as threads).

References

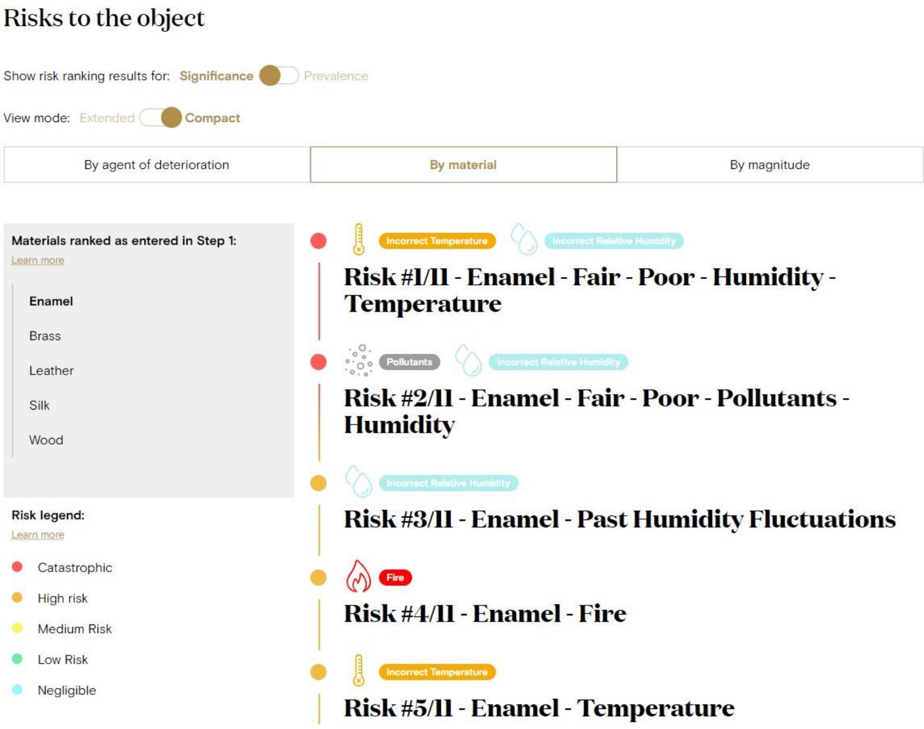
- Barclay R.L., C. Dignard and L. Selwyn, *Caring for metal objects* (online resource: Preventive conservation guidelines for collections), Canadian Conservation Institute, 2018.
- Göpfrich J., N. Frankenhauser and K. Mackert, *Wettlauf mit der Vergänglichkeit. A Race against Transience*, Offenbach, Deutsches Ledermuseum / Schuhmuseum Offenbach, 2012.
- Tétreault, J., *Agent of deterioration: Pollutants* (Web Resource: Agents of deterioration), Canadian Conservation Institute, 2020.
- Werner, U., et al., *The removal of metal soaps from brass beads on a leather belt*, in *Studies in Conservation*, 57(1), 2012, p. 3-20.

The output can be interpreted in two ways:

- The risk of loss of value is shown when the user ranked the materials according to ‘significance’ in the first step and when the slide-button on the result-page is set on ‘significance’.
- The risk of losing material important to the structure of an object is shown when the user ranked the materials according to ‘prevalence’ in the first step and when the when the slide-button on the result-page is set on ‘prevalence’.

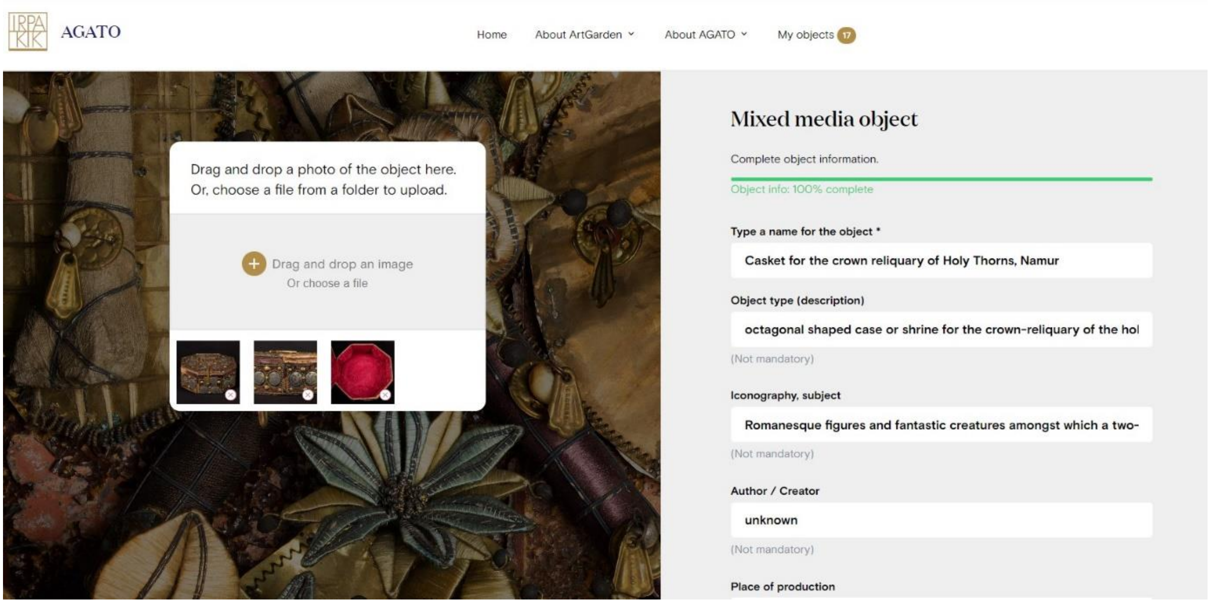
The output-page offers different possibilities:

- Results can be viewed in a ‘compact’ way, only the titles of the ranked risks are mentioned to allow a better overview. A user may choose to slide the button between ‘extended’ and ‘compact’.

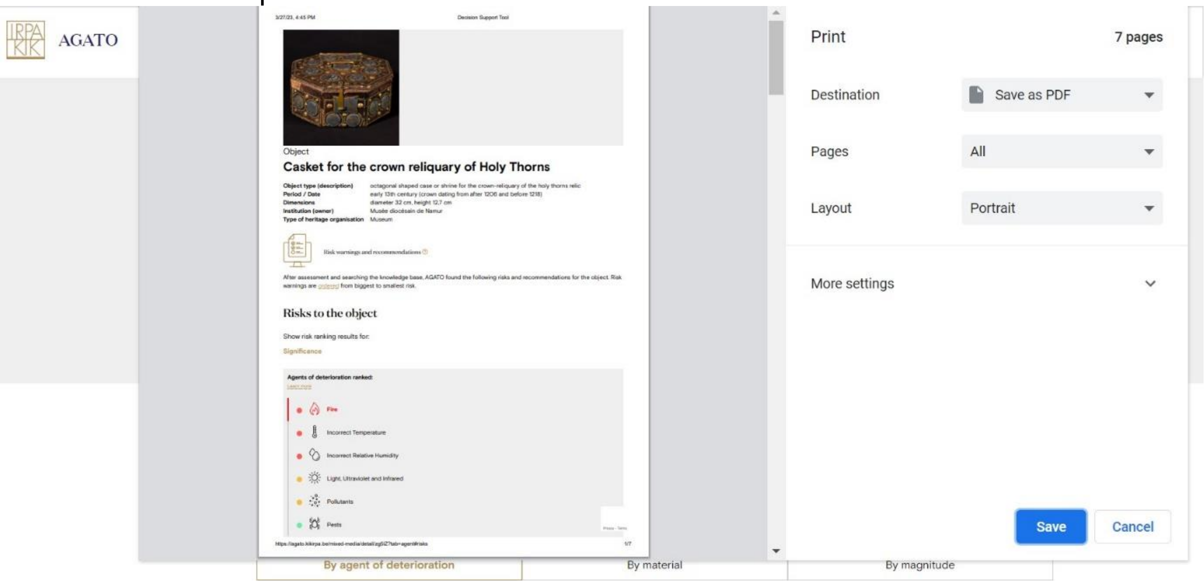


- The object can be duplicated to create a ‘copy of the object’ including all information filled out earlier. This may be used to compare different situations, for instance difference in possible risks to the object when it is conserved in another environment (storage, exhibition, display case,…), or the difference for an object before or after a conservation treatment. In that case answers can easily be adapted using the ‘overview’ by clicking an environmental hazard to be directed to the question and modify the answer.

- Using ‘edit object’ more (curatorial) information on the object can be registered, administrative data such as the inventory number, owner, iconography, dimensions, repository,… (not mandatory)



- Results of every assessment are saved within a user’s account, on the server of KIK-IRPA, only visible to its administrator. Objects or assessments are not accessible to the public.
- To use the results of an object assessment, they can be exported by using the ‘print’ button and create a pdf. All administrative data filled out in ‘edit object’ will be used as a header for this pdf.



Annex 4 : Process of the in-depth case study ARTGARDEN / AGATO : Casket for the crown reliquary of Holy Thorns

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Federaal wetenschapsbeleid
INSTITUT ROYAL DU PATRIMOINE ARTISTIQUE
Politique scientifique fédérale

Projet ArtGarden, QuiskScan© en fonction du case-study : Coffret-écrin de la couronne-reliquaire des saintes Épines

Localité :	Namur
Institution ou collection :	Trésor de la cathédrale Saint-Aubain, Musée diocésain
Titre de l'objet :	Coffret-écrin de la couronne-reliquaire

Personne de contact : Hélène CAMBIER
Musée diocésain
Place du Chapitre 1
5000 NAMUR
helene.cambier@rnamur.be
marjolijn.debulpaep@kikirpa.be

Projet ArtGarden

Cellule(s) IRPA concernée(s) :	Conservation préventive
Responsable de la (des) cellule(s) :	Marjolijn Debulpaep
Personne de contact IRPA :	marjolijn.debulpaep@kikirpa.be
Date:	2021
Rédacteur(s):	Elke Otten

Description de l’objet

No d’objet IRPA	10026545
Commune	Namur
Institution	Trésor de la cathédrale Saint-Aubain, Musée diocésain
No d’inventaire	7
Titre de l’objet	Coffret-écrin de la couronne-reliquaire
Auteur	Inconnu (émaux limousins)
Date	XIIIe siècle
Matériaux	Multiples : bois, cuir, métal (cuivre ?: clous, tringles, émaux), verre, textile
Dimensions	hauteur : 12,7 cm diamètre max.: 32 cm
Propriétaire	Évêché de Namur

Introduction

Ce rapport veut décrire le processus de travail d'un Quiskscan qui a été mené dans l'objectif de mieux comprendre les conditions de conservation du coffret-écrin de la couronne-reliquaire et les risques pour cet objet.

Contexte

Le coffret-écrin était transféré à l'IRPA pour une étude préalable, un constat d'état complet et la restauration. L'œuvre, composé de différents matériaux, présentait des dégâts certains suite au réactions différenciées de ces matériaux aux diverses fluctuations atmosphériques (humidité relative et température).

A cet occasion, le projet ArtGarden, qui se focalise sur la conservation préventive d''historical mixed-media objects', a souhaité d'intégrer le coffret-écrin comme case-study, étant un exemple parfait d'un objet historique multi-matériaux.

En complément des recherches prévues et traitements planifiés, la recherche dans le cadre du projet ArtGarden se concentrerait sur les interactions possibles en les différents matériaux et l'analyse des risques de l'endroit d'exposition permanent du coffre-écrin.

Dans le même projet, un instrument en ligne est développé afin d'assister à la prise de décision en fonction de la conservation préventive pour les œuvres composites historiques. Cet instrument, AGATO, offre une analyse des risques automatisée. Pour mettre à l'épreuve la qualité de cette analyse et permettre d'affiner la fonctionnalité de l'instrument, il a été décidé d'également effectuer une analyse des risques en pratique.

La méthode du QuiskScan©, généralement utilisé pour arriver à la bonne compréhension de la situation d'un ensemble d'une collection vis-à-vis des risques encourues, a été choisie et appliquée à la situation d'un seul objet, notamment celui du coffret-écrin. Dans le rapport qui suit, les différents étapes de ce processus sont expliquées brièvement.

Processus de travail

Cartographier les conditions de conservation

Visite du lieu d'exposition

Le 12 novembre 2020, deux membres de la cellule de la conservation préventive ont visité le Musée diocésain de Namur, où le Trésor de la cathédrale Saint-Aubain est conservé.
Pendant cette visite, un entretien a eu lieu avec la conservatrice du musée et seul membre de personnel de cet institution, Hélène Cambier. Lors de cet interview, un vaste questionnaire (115 questions) a été parcouru, afin de comprendre si les œuvres pourraient être atteint par les risques liés aux dix agents de détérioration au niveau de la gestion, l'équipement du bâtiment et l'état du bâtiment.

L'espace d'exposition du coffret a été documenté, par un plan, une documentation photographique et la mise en route d'une campagne de mesure.[1]

Campagne de mesures

Pour une meilleure compréhension du climat de l'endroit d'exposition, un datalogger a été placé pendant la période 12/11/2020-26/02/2121[2], mesurant la température et l'humidité relative. L'instrument est installé à l'intérieur de la vitrine du coffre-écrin, avec en parallèle une sonde qui mesurait à l'extérieur de la vitrine.

Pour avoir une idée de l'exposition à la lumière et les rayons UV, un datalogger est posé sur le socle du coffret-écrin à l'intérieur de la vitrine pendant la période 27/02/2021 – 26/02/2021.[3] Différents types d'exposition à la lumière et lux UV ont été testés : avec et sans cloche de vitrine, et avec et sans couverture textile sur le dessus de la cloche. Ceci devrait permettre de comprendre l'effet de la mesure de protection contre le rayonnage directe de la lumière du jour introduit par le musée. Ci-dessous les différents situations :

A partir du 27/01 : mesures SANS la cloche de plexiglas ;
A partir du 04/02 : AVEC la cloche de plexi ET un tissu qui couvre le dessus de la cloche ;
Vers le 10-11 /02 : neige. Couverture neigeuse sur la grande baie vitrée du toit.
A partir du 11/02 : cloche SANS tissu de couverture ;
A partir du 19/02 : cloche AVEC tissu de couverture.

Pendant deux visites sur place, la lumière et les rayons UV ont été mesuré ponctuellement, au niveau des objets exposés en vitrine et en dehors de vitrine. Les mesures sont prises le 18/12/2021 et le 01/04/2021, deux fois pendant une journée ensoleillée.

Les instruments suivants ont été utilisés pendant la campagne de mesure :

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[1] La campagne de mesure était très limitée dans le temps. Pendant la pandémie du COVID-19, l'organisation des missions était perturbé.

[2] Attention, la campagne de mesure ne comprenait qu'une saison, l'hiver. Pour une étude climatique complète, il est nécessaire d'avoir les données continues d'au moins une année.

[3] Attention, il s'agit d'une période très limité. Les mesures ont été prises pendant l'hiver. Le degré d'intensité de luminosité peut fortement changer selon lest saisons. Les résultats ne concernent que la période hivernale 2020-2021.

Hanwell ML4000 Series Datalogger
Sensor (external): Lux/UV
Style : Stand-Alone
Serial No: 1018-00438
Standard Lux range: 0 – 5000 Lux
Standard UV power: 1W/m²
Data: 27/02/2021 – 26/02/2021

Elsec Monitor 765C
lux-UVmètre et datalogger
Visible wavelength range: 400-700nM (CIE response). No correction required for different light sources
Visible power range: 0.1 - 200,000 Lux (0.1 – 20,000 Foot-candles)
UV wavelength range: 300-400 nm
UV power range: 2 - 10,000 mW/m
UV proportion range: 0 - 10,000 mW/Lumen
Accuracy: Light 5% and UV: 15% ± 1 displayed digit
Mesures ponctuelles, data : 18/12/2021, 01/04/2021

Mostralog thermohygrometer and data logger
Device for external + internal measuring with external sensor
Operating range -18°C to +70°C
Temperature sensor
    Measuring range -18°C to +70°C,
    Accuracy ±0.5°C(5°C to 45°C);
    Resolution 0.1°C
Humidity sensor
    Measuring range 0 to 100% RH
    Accuracy ±2% RH (10 to 90% RH)
    Resolution 0.1% RH

Le plan du musée et sa collection

Pendant la visite, une partie de musée et sa collection sont 'cartographiés'. L'aménagement de la salle d'exposition inférieure a été repris sur un plan basique (verrière, porte,…), également indiquant les équipements techniques (électricité, spots, ventilation, caméras,…).
Sur ce plan, l'emplacement de la collection a été reporté. Les meubles d'exposition sont situés dans l'espace et les œuvres exposés hors vitrine sont dessinés sur le plan. Les différents types de collections (ou sous-collections) sont indiqué sur le plan par une couleur caractéristique.

Finalement, par-dessus ces informations est calqué l'exposition des objets au risque liés à chaque agent de détérioration[4]. Ceci montre où dans l'espace et à quel degré les objets sont exposés par exemple à la lumière ou un autre agent de détérioration.

[4] Les agents de détérioration: forces physiques, vol et vandalisme, incendie, eau, ravageurs, polluants, lumière, ultraviolet et infrarouge, humidité relative inadéquate, température inadéquate et dissociation. https://www.canada.ca/fr/institut-conservation/services/agents-deterioration.html

Le QuiskScan©

La collection exposé est caractérisée. Après concertation avec la conservatrice, la collection est subdivisée en sous-collections selon les différents types de pièces de collections. Ces sous-collections représentent également des catégories de vulnérabilité de matériaux différents. Chaque sous-collection est valorisé par la conservatrice: sa valeur relative aux autres sous-collections à été évaluée.

Ensuite, pour chaque sous-collection, les risque sont analysés. Premièrement le degré de vulnérabilité des différents matériaux par rapport à un agent de détérioration est estimé. Après, l'exposition de la sous-collection à un agent de détérioration est estimé (sur base de l'interview, le plan et les données mesurés).
Ces deux paramètres ensemble aident à déterminer le niveau de risque.

Pour obtenir une vue générale de la situation de la collection et comprendre où on risque la plus grande perte de valeur à la collection, et combien de a collection serait perdu si jamais elle est atteinte par ce risque, tous les données rassemblées sont combinées :

- Le nombre d'objets dans une sous-collection
- La valeur attribuée à une sous-collections
- La vulnérabilité d'une sous-collections à chaque agent de détérioration
- L'exposition d'une sous collection à chaque agent de détérioration
- Le niveau de risque encouru

Le résultat d'un QuiskScan peut révéler les points d'attentions importants, et peut aider à décider où mettre ses priorités. Il faut cependant faire attention quant à l'interprétation des résultats, et garder en tête que les chiffres attribués pour chaque paramètre (ex. la valeur ou la vulnérabilité) peuvent fortement influencer le résultat final.

Résultats

Les résultats du trajet complet sont présentés dans une présentation power-point le 03 juin 2021.