CONSERVING HISTORIC HOUSE COLLECTIONS: THE EPICO METHOD APPLIED TO THE CHÂTEAU DE MAINTENON

Danilo Forleo, Nadia Francaviglia

Résumé Mise au point au cours de quatre ans de recherches dans le cadre du programme EPICO (*European protocol in preventive conservation*) piloté par le château de Versailles, la méthode d'évaluation présentée a été spécifiquement conçue pour l'application aux collections exposées des demeures historiques ouvertes au public.
La méthode a pour objectif de mettre en lumière les causes d'altération agissant sur les collec- tions, dans le but de prioriser les actions à mettre en place et établir un plan de conservation préventive. Afin de rendre plus simple la compréhension de la méthode, nous présentons ici son application pratique en 2019 aux collections et aux décors immeubles du château de Maintenon, dans le département d'Eure-et-Loir.

Abstract This assessment method has been developed over four years of research within the framework of the EPICO programme (European Protocol in Preventive Conservation) under the Château de Versailles's leadership and has been specifically designed to be applied to the displayed collections of historic dwellings open to the public. The method aims to highlight the alteration causes affecting collections with the aim of prioritizing the measures to be implemented and to establish a preventive conservation plan. To simplify the understanding of the method, we present here its practical application in 2019 to the immovable collections and décor of the castle of Maintenon in the Eure-et-Loir department in France.

Resumen Desarrollado durante cuatro años de investigación como parte del programa EPICO (Pro- tocolo europeo en conservación preventiva) pilotado por el Palacio de Versalles, el método de evaluación presentado fue diseñado específicamente para apli- carlo a colecciones expuestas en residencias históricas abiertas al público. El método apunta a hacer resaltar las causas de alteraciones activas en las colecciones, para priorizar las acciones a implementar y estable- cer un plan de conservación preventiva. Para simplifi- car la comprensión del método, presentamos aquí su aplicación práctica en 2019 a las colecciones y decorados del castillo de Maintenon, en el departamento de Eure-et-Loir.

Key words preventive conservation, assessment method, sampling, zoning, alteration causes, collections and immovable decor, historic houses, prioritizing measures

The EPICO research programme and partnership with the Château de Versailles

The EPICO research programme

Since 2014, the Public Establishment for the Château, Museum and National Estate of Versailles has lead EPICO[1], a new research programme. The aim was to design an assessment method for conservation suited to the specificities of historic houses which are open to the public. This programme draws from the the particularities of Palace-museums, with Versailles as an emblematic example.

The sheer size of the estate and the wealth of collections, the events, and valorizing activities are extraordinarily diverse, which brings the first challenge in preventive conservation: identifying the most sensitive rooms and collections as well as the main alteration causes on the grand scale of such heritage.

Then, the project of ensuring the safety of the technical networks and refurbishing the air-treatment system for the south-central wing of the château (2015-2019) required an assessment of conservation conditions in the royal apartments. This was needed to gain insight into the extent to which the renovation works could be beneficial and to estimate the cost of risks. These sensitive and exciting questions were the subject of lively discussions between the establishment's different departments.

For instance, the climatic risk analysis provided by engineers, and the collection alteration survey conducted by the conservation team would sometimes deliver conflicting results, in turn leading to opposing recommendations. Hence a need to adapt the thresholds for climate prescriptions, as museum standards are unattainable within historic houses, and to seek an assessment method that highlights the cause and effect relationships for alterations, in order to reach an accurate diagnosis.

These two starting points lead to the thought process at the inception of the EPICO[2] European research programme. Taking the historic house as a conservation system that can be modeled, the Château de Versailles decided to work with other institutions and members of the European Network for Royal Residences (ARRE)[3].

The 2015-2017 programme was carried out over three stages: a review of existing assessment methods which may be adapted to the aims of EPICO[4], an experimental phase with a full-scale test of selected methods within four historic houses, and the design of the new EPICO method. In 2017, a first publication (Forleo et al., 2017) and the preventive conservation in historic houses and palace museums symposium held at the Château de Versailles enabled us to disseminate the results of the programme (Forleo, 2019), and to extend the scope of discussions to an international level[5].

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[1] European protocol in preventive conservation.

[2] http://www.europeanroyalresidences.eu/epico/

[3] The five partners for the 2014-2017 programme are : in France, the Château de Versailles and the Research Centre for the Château de Versailles, the Network of European Royal Residences, the palace-museum of king Jan III in Wilanów, Poland, and the Fondazione Centro per la conservazione e il restauro dei beni culturali « La Venaria Reale » in Turin, Italy.

[4] The five prevailing criteria for the existing assessment method and, later on, in the design of the new assessment method were the following : specific to historic house collections, simple, using a systemic approach, able to provide a global view of the conservation conditions and state, tranferable to other houses regardless of their complexity, size and collection management.

[5] At the close of the first phase of the EPICO programme, the 3 day symposium saw 51 speakers, with 5 round tables, 160 attendees from 16 countries in Europe, North America, South America and Asia. The symposium was supported by 7 international patrons : ArdenPlast, Boston University, Polygon, Testo, Abiotec, CTS, ILTI Luce.

On the strength of these results, the Château de Versailles renewed the EPICO programme for 2018-2020. This new phase is dedicated to implementing the new method in different residences, also members of ARRE, and to training historic-house professionals as well as preventive conservation students in Europe. In line with the scientific process, the new method, at this stage, needs to be applied to different institutions in order to be refined, and corrected, and to produce an application manual (2020). In turn, new partner institutions [6] stand to benefit from *ad hoc* and specific EPICO method preventive conservation training.

The assessment of the Château de Maintenon in 2018 was the first implementation of this new phase in the research programme[7] : the Eure-et-Loir département Council, which runs the site, thus benefited from a precise diagnosis, i.e. the first stage in writing a preventive conservation plan. At the same time, thanks to this test, the research team was able to identify some aspects of the method to improve. The results from this new implementation were presented during a dedicated meeting of the programme's scientific committee, attended by representatives from the Eure-et-Loire département Council, at the Château de Maintenon.

The Château de Maintenon

The Château de Maintenon, a listed Historic Monument, provides a rare example of a residence that was restored and refurnished during the 19th century, with a historicist view of the Grand Siècle (the 17th century). All significant construction periods of the château remain visible.

The château has been documented since the 13th century, and has been continually expanded and embellished by its successive owners; notable among them was Madame de Maintenon, Louis XIV's second wife. The Château remained within the same family from the late 17th century up to 1983, when it was bequeathed by Mr. and Mrs. Raindre, descendants of the Noailles family, to the Mansart Foundation. The Eure-et-Loire département Council took over the management of the site and its collection in 2005. Since then, the first coordinated conservation and valorizing measures have been rewarded by an increase in attendance, which has doubled, from 2013 (35 000 visitors/year) to 2019 (75000 visitors/year).

A first inventory campaign made it possible to draft a pre-inventory listing 3700 works (paintings, sculptures, graphic arts, furniture, decorative arts, and immovable décor ornaments), practically all of which are displayed in the fifteen rooms of the château open to the public. Occasional restoration works have preserved and highlighted the most fragile decorative elements. As an exception within the field of French palace museums, traditional collection upkeep practices have been handed down from family to family, up to the current conservation managers, and transcribed to an Excel document for each collection item displayed. Besides these conservation-restoration activities, the event policy takes up much of the château team's time, in particular the Christmas theatrical visits of the *Fabuleux Noël,* and causes the conservation challenge of works being moved, but also constitutes an important valorizing opportunity.

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[6] The five new partners for the 2018-2020 programme are : the Château de Versailles, the Network of European Royal Residences, Parques de Sintra – Monte da Lua, Portugal, Prussian Palaces and Gardens of Berlin-Brandebourg, Germany, Château de Maintenon, University Paris 1 - Panthéon Sorbonne.

[7] For more information about the 2018-2020 EPICO programme and its aims, download the EPICO brochure from the Network of European Royal Residences : http://www.europeanroyalresidences.eu/arre-cntnt/uploads/2019/09/Brochure-EPICO_EN.pdf

In 2017, the département Council, realizing the management history of the estate was taking a new turn, enlisted the help of specialists to support the conservation team in writing a new Cultural Scientific Project and a Preventive Conservation Plan.

In this context, the partnership with the Château de Versailles and the EPICO research team constituted an exceptional opportunity for both institutions. The first collection surveys had shown alterations whose nature was plain to understand: climate, light, pests, handling, works left unprotected. But before committing the means for remedial measures, a diagnosis of active causes using a scientific approach was needed in order to validate, quantify and legitimize any corrective steps.

The importance of this preparatory phase of the preventive conservation plan cannot be overstated. This stage, which occurred over 2018 and was very demanding for the staff, benefitted from specific support. Indeed, at my request, the EPICO programme researchers agreed to share their expertise during this preliminary stage in order to provide training and support.

Their skills are especially valuable as their research topic – the adaptation of preventive conservation methods to the particular case of historic houses- favours a realistic and pragmatic approach which, beyond architectural constraints and possibilities in terms of means, also takes into account historic-house specific stakes. Among others, we can mention audience satisfaction, when enjoying the atmosphere of a lived-in house, that can be lost when it is over-protected; the hosting of receptions, concerts, and performances, which carry on a tradition, but, when they are frequent, can cause a threat to the work, which needs to be objectively defined. By the end of this preparatory phase, in 2019, it will be up to the managers to create the preventive conservation plan along the following lines: collection assessment – defining priorities- recommendations- phasing – defining human and financial means.

Furthermore, preventive conservation will be the object of a chapter in the Scientific and Cultural Project (PSC), much like, for instance, knowledge of the audience[8].

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[8] Saule, B., 2018, Brief on collection restoration priorites in view of establishing a provisionnal budget, with appendix : Pre-inventory by E. Massouline and S. Baruq, initial preventive conservation recommendations by D. Forleo, conservators opinions for different collection types.

Stages of the EPICO method and assessment results

STAGES OF THE EPICO METHOD

1 Pilot inspection

2 days

2 Zoning / Sampling

5 days

3 Data collection

7 days

4 Diagnosis

5 days

5 Recommendations

1 day

20 work days

Figure 1 Stages in the EPICO method. © EPICO team, château de Versailles.

Introduction to the different stages of the method

The whole assessment process took 19 workdays over a year-long partnership:

- 2 team members from Maintenon worked for the full assessment period;
- 5 members from the EPICO team, from the Château de Versailles, assisted the Maintenon with the main stages of the method for a total of 5 days, especially with condition reports and data processing.

In spite of a fairly limited number of rooms affected by the assessment (23 in total), the Château de Maintenon boasts a very great number of collections on display: about 3 700 objects and décor elements have been listed by the in-house team during an inventory which took place prior to the implementation of the method (this includes 2200 antique books – not within the scope of the mission). This great variety of objects and immovable décor didn't allow, within the allocated time and manpower, for an object-by-object, total assessment of the collection. Thus, we decided to

proceed to a selection of rooms to be assessed and to implement the statistical method designed by the EPICO team during the research phase, in 2018, with support from Fabrice Baudin, a statistics expert from Vitruvian Consulting.

With the museum's in-house team, we elected to include the following in the scope of the assessment :

- All rooms open to visitors;
- « Visible » but not accessible rooms (which can be seen from the outside but not entered by visitors);
- Rooms which are usually closed to the public but open for events (such as the *Fabuleux Noël,* which takes over a large part of the Château during the Christmas holidays);
- Rooms featuring collections or period décor elements, which are not open to visitors but are used by the staff.

Stage 1. The pilot inspection

1
THE PILOT INSPECTION

Figure 2 An EPICO team meeting. Room inspections, overall insight into the scale of the site and collections, meeting with the collection managers, discussions between the Maintenon and Versailles teams prior to the assessment.

Stage 1 general description

The first support document for the application of the EPICO method is the Pre-inspection form: filling this out involves collecting data about the collection, the building, and the institution as a whole, which helps the local team to gain greater insight into existing issues ahead of the assessment itself (**fig. 3**).

Pre-inspection form
EPICO conservation assessment

AIMS OF THE PRE-INSPECTION SURVEY

To prepare for the inspection, fill out this form in order to provide a synthetic image of the complexities of the collections, building(s), and preventive conservation practices implemented by the institution. This inspection will serve as a basis to identify the areas in the house which will be assessed and to prepare pre-inspection documents.

Table of contents

1. General Information

2. Site

3. Collections

4. Environnement

5. Building use

If the museum is made up of annexes which fonction indepentently or differently enough from the main building, or if the buildings feature different uses, museographies, or visiting and operating systems, complete sections 2, 4, 5 for each annex building.

Assessment essentials :
Documents needed
❑   List of works per room (ideally extracted as an Excel file – Appendix 1)
❑   Castle plans with floor areas and room names
❑   Visiting paths
❑   Annual visitor number

Documents to fill out in view of the assessment :
❑   Collection summary table for each exhibition room and object type (Appendix 2)
❑   Room characterization table (Appendix 3)
❑   Any document summarizing the history and use of the house (brochures, visitor documents, event flyer)

Danilo FORLEO - Nadia FRANCAVIGLIA

Figure 3 Pre-inspection form (table of contents). © EPICO team, Château de Versailles.

Using the answers provided, it is possible to proceed to zoning and sampling the collections to be assessed (stages 2 and 3). A pilot inspection day always proves useful: it is a chance to clarify any question the in-house team couldn't answer independently.

Time: it took an in-house team of two one day to fill out the pre-inspection form.
The pilot inspection on location was done by both Maintenon and Versailles teams during 1 day (6 people altogether).
Equipment: Microsoft Power Point® form, inventory data, staff survey.
Results: the clarified the complexity of operations for the Château de Maintenon's rooms, including exceptional events and mediation activities which are a part of museum life.

Form description

Drawing inspiration from the pre-inspection form created by the *Getty conservation institute* in the 1990s (Wolf, 1998) and translated by Florence Bertin et Denis Guillemard for the Paris 1 University Preventive Conservation Masters, the form has been adapted to the specific case of historic houses. It aims to paint a synthetic picture of the complexities of the collections, the building(s), and preventive conservation practices within the institution. This inspection provides a foundation for identifying the areas in the house which will be assessed and to put together the documents ahead of the assessment itself.

The form's five sections (General information - Site - Collections - Environment - Operations) follow the Getty model, but the contents for each section were altered to fit specific traits of historic houses open to the public. Some questions were added regarding upkeep practices, exceptional events, use of rooms for other purposes (such as serving as a film shoot location), the history of the immovable décor, and the collection (travels, restoration, re-creations), the visit route(s) and visitor numbers.

Collecting the needed data for the pre-inspection form ignited discussions within the team, improved collection and site knowledge, and highlighted strengths and weaknesses in the management of the palace-museum. These points were later discussed with the site managers with a view to clarifying responsibilities and planning the tasks to come.

The team must be equipped with these essential tools for the assessment:

- documents to be found ahead of the assessment: list of objects per room (ideally extracted to an Excel spreadsheet - appendix 1) - plans of the château with floor area and room names – visit route(s) salles – annual visitor figures;
- documents to prepare for the assessment: room characterization table (appendix 2 – *Zoning*) – overview of collections per room and object typology table (appendix 3: *sampling*) – any document summarizing the history and operations for the house (brochures, visitor documents, event flyers).

Stage 2. Zoning the château and sampling the collections

Stage 2 general description

The purpose of zoning the house is to identify homogenous areas within the building, taking into account certain characteristics which can especially impact collection and décor conservation.

Objects and décor elements are selected for assessment by sampling based on the earlier zoning results, thus ensuring an overall picture of the house's condition. The sampling method used is two-stage clustering (here a cluster represents an object typology: painting, sculpture, immovable décor elements, furniture, art objects, etc.), which has proven to be the most effective after many statistical tests (Forleo, Francaviglia, 2018).

ROOM NAME	FLOOR AREA	FREE OR GUIDED VISIT	ACTIVITY	ORIENTATION	MUSEOGRAPHY	Human impact / m²	HUMAN IMPACT LEVEL M2	AREA
Cenotaph	16,64	FREE VISIT / GUIDED VISIT	VISIT	E	APARTMENT	0,00	Very low	3
Maréchalde Noailles Antiroom	33,7	FREE VISIT /GUIDED VISIT	VISIT-EVENT-FILM SHOOT	N	APARTMENT	7,25	Very high	64
Red Salon	68,36	FREE VISIT / GUIDED VISIT	VISIT-EVENT-FILM SHOOT	S	APARTMENT	3,37	High	56
Grand salon	71,55	FREE VISIT / GUIDED VISIT	VISIT-EVENT-FILM SHOOT	SE	APARTMENT	3,22	High	58
Library	48,8	FREE VISIT/ GUIDED VISIT	VISIT-EVENT-FILM	W	APARTMENT	4,72	High	58

Figure 4 Multi-criteria zoning : Zoning makes it possible to group rooms sharing similar characteristics (museography, visit type, human impact and orientation) and thus to create areas with potentially the same impacts on collections. © EPICO team, Château de Versailles.

Time : 2 people from the Versailles team performed the zoning over 2 days.
Equipment : dedicated Excel documents (appendix 2 to pre-inspection form).
Results : for 23 rooms, 14 homogenous areas were identified using the 5 criteria (visit type – human impact - activities – human impact- orientation - museography).

As the EPICO method has been designed especially for the purpose of assessing historic house collections, characterising the rooms constitutes a fundamental stage for understanding the causes affecting objects of existing risks in the house, and to treat them depending on the severity of their effects. The rooms are classified using 5 criteria:

- Visit type: free visits, guided visits, both free and guided visits, no visits/closed to the public;
- activities: visits alone, visits+events+film shoots, film shoots+ events, living area and/or office, no activity;
- human impact: this index, specifically introduced in the framework of the EPICO programme, takes into account the room's floor area, visitor figures, and opening days/room use depending on the time of year;
- orientation: north, south, east, west, double easter orientation (NE or SE), double west orientation (NW or SWO), double east-west orientation, skylights, windowless room. In architecture, it is usually considered that southern and western orientations have a greater impact on a room's climate than other orientations ;
- museography: gallery, apartment[9].

These combined criteria result in a total of 505 possible zones (referred to as « classes »), each identified by a number.

For the Château de Maintenon, out of the 23 rooms assessed, we have identified a total of only 14 classes. The careful selection of criteria ensures that rooms within a class share the same features; thus objects and décor elements conserved within the rooms of one class will undergo very similar conservation and use conditions.
The sampling was performed on the basis of these homogenous zones in order to provide an exhaustive picture of the collections (**fig. 5**).

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[9] Apartment display type : the collection is shown in the context of the house in use depending on how past owners would have used and presented them. Gallery display type : the collection is displayed to highlight its historic and artistic value, with an educational purpose defined by the owners or the heritage management.

Figure 5 Zoning map. © EPICO team, Château de Versailles.

Human impact

The issue of access to historic sites has been examined extensively (Lithgow *et al.,* 2008). We are aware of the fact that visitors should not be considered as an alteration factor, but rather as an enhancement factor for other risks, and we had to assess the impact of attendance on the room's conservation conditions (dust, hence dusting frequency, light – and opening the shutters, vandalism, visitor accidents, etc.). These problems are of course particularly strong at a location such as the Château de Versailles, which sees a high attendance, especially at peak periods during the year.

Different approaches of this factor which we named *Human Impact* are based on how precise available information is.

If we know precisely how many visitors per day in a given room:

« n » being the number of open days:

$$\sum_{j=1}^{n}$$

    n Number of people in the room during one day

    $\sum$ Surface area

This is the ideal case.

If we divide the year into periods:

low season;

high season;

exceptional days (Heritage Days etc.).

For each period, we need to know the average number of people per day and the number of days per period.

$$IH = \frac{(NB\ ppl\ LS\ *\ NB\ days\ LS) + (Nb\ ppl\ HS\ *\ Nb\ days\ HS) + (Nb\ ppl\ ED\ *\ Nb\ daysED)}{Surface\ area}$$

For example:

high season: 15000 people/day on average for 100 days;

low season: 4000 people/day on average for 200 days;

exceptional days: 20000 people/day on average for 3 jours.

Surface area: 50 m²

= 47200

If we have only limited information – i.e. only the annual number of visitors for a given institution – and if there is no high or low season- the average number of visitors will be the total figure divided by the maximum number of open days for the institution. This average number will be multiplied by the number of days the room is open and divided by its surface area.
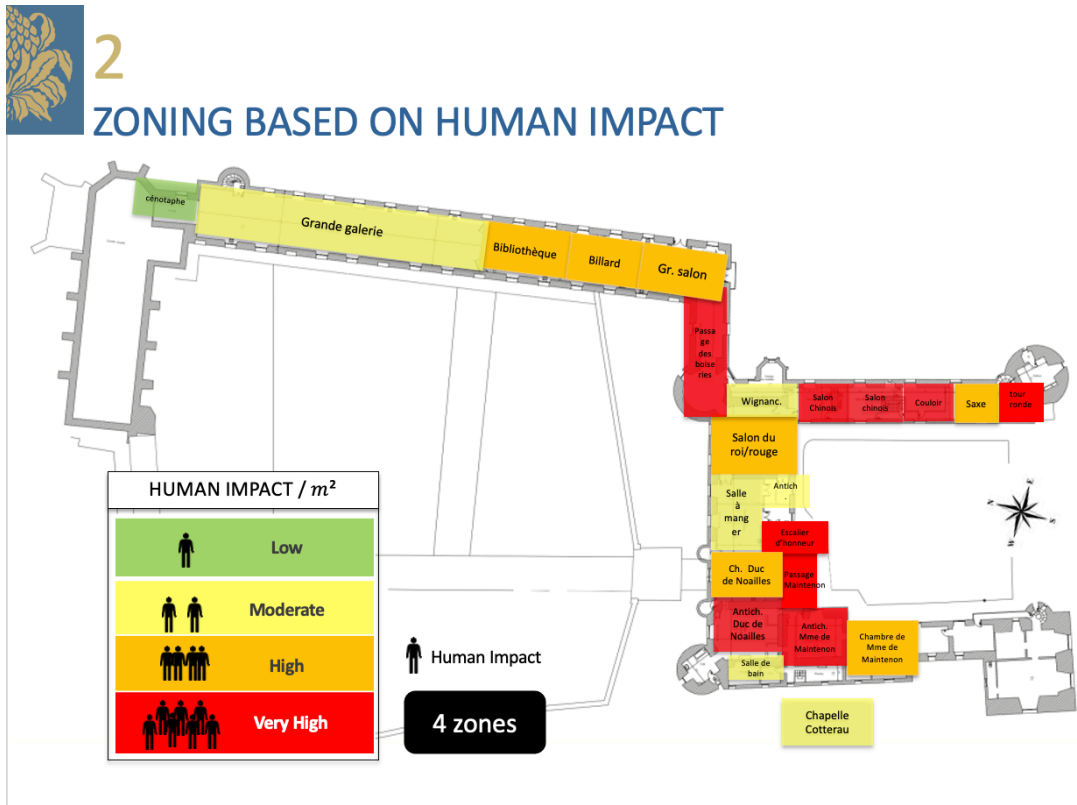
2
ZONING BASED ON HUMAN IMPACT

Figure 6 Map of zones based on human impact. © EPICO team, Château de Versailles.

Sampling description

2
THE SAMPLING

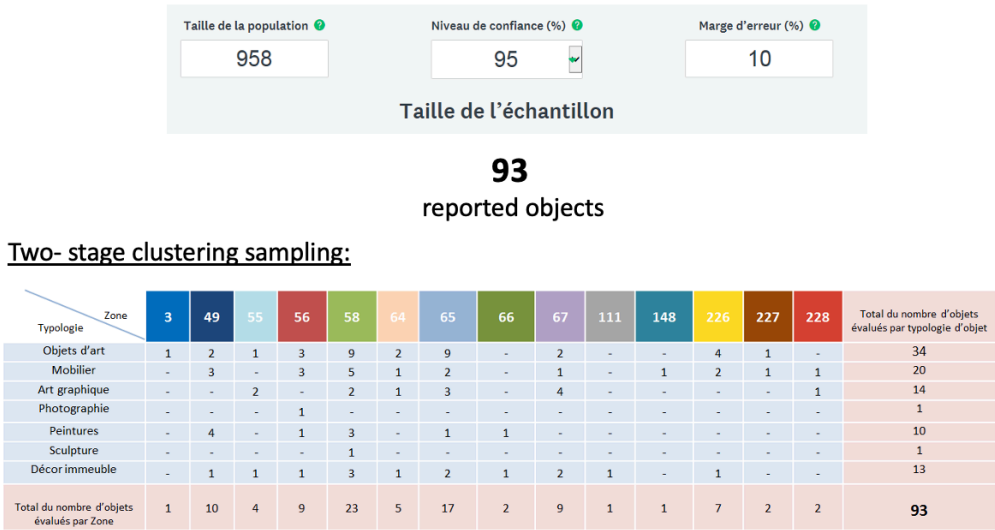| Taille de la population ❓	Niveau de confiance (%) ❓	Marge d'erreur (%) ❓
958	95	10

Taille de l'échantillon

93
reported objects

Two- stage clustering sampling:

Typologie / Zone	3	49	55	56	58	64	65	66	67	111	148	226	227	228	Total du nombre d'objets évalués par typologie d'objet
Objets d'art	1	2	1	3	9	2	9	-	2	-	-	4	1	-	34
Mobilier	-	3	-	3	5	1	2	-	1	-	1	2	1	1	20
Art graphique	-	-	2	-	2	1	3	-	4	-	-	-	-	1	14
Photographie	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Peintures	-	4	-	1	3	-	1	1	-	-	-	-	-	-	10
Sculpture	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Décor immeuble	-	1	1	1	3	1	2	1	2	1	-	1	-	-	13
Total du nombre d'objets évalués par Zone	1	10	4	9	23	5	17	2	9	1	1	7	2	2	93

Figure 7 Object sampling. © EPICO team, Château de Versailles

> Time: the Versailles team (2 people) performed the sampling over 3 days
> Equipment: dedicated Excel spreadsheets (appendixes 2 and 3–pre-inspection form, data base from the collection inventory including inventory numbers of object, fictional numbers attributed to décor elements or objects which have not been inventoried yet).
>
> Results:
> Total number of works inventoried: 1500 objects (antique books did not enter in the assessment scope);
> 23 rooms selected and analyzed;
> Number of works covered by our assessment: 891 objects/958 items including décor elements;
> Number of works actually reported with sampling technique: 93 items (including 13 immovable ornaments).

Based on statistical research from 2018, we found that:

the cluster which best represents the entirety of collections displayed in a historic house was collection typology and area cluster;

sampling with a 95%[10] confidence and a 10%[11] margin of error is sufficiently representative for the entire collections in a historic house with highly diverse collections.

Out of a total population of 958[12] objects /ornaments covered by the scope of the assessment of the Château de Maintenon, we needed to report on 93 objects. This amount was easily done by the committed team and helped to meet deadlines.

We naturally calculated how many objects belonged to each category for each class:
- paintings;
- sculptures;
- furniture;
- art objects;
- immovable decorative ornaments (fabric wall coverings, wallpaper, leather, stuccos, chimneys, mirrors, boiseries …);
- graphic arts ;
- other typologies (areas will vary depending on an institution's specificities)

In order to make this stage clearer to readers, here is the example of the class 58 cluster, spanning 5 rooms:
- Madame de Maintenon's bedchamber;
- library;
- billiard room;
- grand salon;
- Saxe room.

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[10] A 95% confidence level means the same results will be reached in 95 % of cases.

[11] The margin of error shows the extent to which the sample is likely to represent the population as a whole. The margin of error can be seen as a way to measure the sample's accuracy. The lower the margin of error, the more you can consider your data is reliable. The higher it is, the further your results from the total poplation.

[12] These items are from the rooms which are open to visitors an within the scope of our assessment. The inventoried objects amounted to 3700 (including 2200 antique books, beyond our scope). We grouped the items, in particular art objects (cups and saucers for instance) and paired frames to paintings/drawings and prints, hence the total of 958.

CLASS	OJECT TYPOLOGY	NB ITEMS CLASSIFIED	NB ITEMS BEDCHAMBER	NB ITEMS LIBRARY	NB ITEMS BILLIARD ROOM	NB ITEMS GRAND SALON	NB ITEMS SAXE ROOM	NB ITEMS total population t	PERCENTAGES	SAMPLE ITEMS	SAMPLE EFFECTIVE NB
58	PAINTINGS	28	0	7	10	3	8		2,92 %	2,63	3
	FURNITURE	49	16	6	16	2	9		5,11 %	4,60	5
	GRAPHIC ARTS	18	0	2	0	3	13		1,88 %	1,69	2
	ART OBJECTS	94	1	26	16	51	0		9,81 %	8,83	9
	TEXTILES	0	0	0	0	0	0	958	0,00 %	0,00	0
	SCULPTURES	11	11	0	0	0	0		1,15 %	1,03	1
	PHOTOS	2	0	0	0	0	2		0,21 %	0,19	0
	IMMOVABLE DÉCORS	32	6	6	6	6	8		3,34 %	3,01	3
	SCULPTURES	11	11	0	0	0	0		1,15 %	2,63	3

Figure 8 Table - example of a sample calculation for a given class.
© EPICO team, Château de Versailles.

We then proceeded to draw 3 paintings out of all the paintings in the five rooms which make up class 58, 5 pieces of furniture, 2 graphic arts items etc. For the entire class, which amounts to 234 objects, we had a sample of 22 objects. The same kind of draw was performed for each of the 14 classes identified, based on present typologies. The draw uses inventory numbers, it is therefore absolutely essential to number each object and décor element with a number (fictional if need be).

Stage 3. Data collection

> Time: 7 days for 2 people.
> Equipment: condition report Excel spreadsheet (featuring sampled objects/ decorative elements), alteration, causes and diagnostic terms visual glossary, flashlight/UV light, camera, sumary of data collected by in house team (climate, pests, visit conditions etc.)
> Results: 93 objects reported, 548 alterations identified.

General description of stage 3

This stage in the method is dedicated to condition reports and analyzing conservation conditions. The reports are carried out in pairs, and the person charged with note-taking must be comfortable using Excel spreadsheets (fig. 9).

ALTERED MATERIALS	ALTERATIONS	SEVERITY	EXTENT	GENERIC CAUSES	ACTIVE or NON-ACTIVE	SPECIFIC CAUSES	DIAGNOSIS
Metal	corrosion/oxydation, dulling	1	3	INTRINSIC DETERIORATION 60%, CLIMATE INTERACTION 40%	ACTIVE	Natural aging of materials	No corrective action needed
Metal	Dust/deposit, accumulation/concretion/soiling, dirt, incrustation	1	3	POLLUTANTS/DUST ACCUMULATION	ACTIVE		Inappropriate cleaning protocols (materials or frequency)
Paper/card	Dust/deposit, accumulation/ concretion/soiling, dirt, Incrustation	1	3	POLLUANTS/DUST ACCUMULATION	ACTIVE		Inappropriate cleaning protocols (materials or frequency)
Paper/card	Exogenous element/projection	4	1	INFESTATION (insects, mold, rodents)	ACTIVE	Instects/non pest animals (flies, spiders, bugs))	Lack of air filtration system (lack of filters, permanent openings : doors, windowns, chimneys)

Château de Maintenon: Grand salon, Salon Chinois II et Grande Galerie
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Figure 9 Excel condition reports. © EPICO team, Château de Versailles.

Ideally, sampled objects should be entered in the spreadsheet ahead of time in order to ease the condition-report process on location. For each object, the identifying data (inventory number, materials, etc.) are noted as well as material sensitivity to alterations mentioned each time by the evaluator[13]. Sensitivity is essential data for the following calculations, as the EPICO method takes into account the severity of active causes (which are causing ongoing damage) as well as materials' sensitivity within a given zone, in order to gain insight into whether priority actions should be taken (or not) against some aggressors.

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[13] The file is modelled to mention sensitivity (or lack thereof) of materials to alteration cause noted by reporter.

Alterations are noted for each altered material and, for each alteration, the extent and severity indices are mentioned as numbers from 1 to 4.

Selecting the right alteration term and extent and severity indices is facilitated by checking the Visual Alteration Glossary which has been the object of research, additions, and corrections from the start of the EPICO programme (Forleo et al., 2017).

For each alteration entered, it is also necessary to enter a generic cause (and specify whether it is active or not), a specific cause, and, if possible, given the data available, a possible diagnosis. The cause and diagnosis manuals are also provided to evaluators before finding possible answers to questions arising during the condition report (fig. 10).

3

MANUALS: ALTERATION, CAUSES, DIAGNOSIS

Figure 10 Alterations, causes, and diagnosis terms manual. © EPICO team, Château de Versailles.

Generally speaking, priority is given to alterations that can reveal information about the rooms' conservation conditions, without focusing on purely esthetic alterations (such as ancient, mismatched touch-ups to paintings) unless one aims to highlight inappropriate interventions which can harm an object's legibility. It must be clarified that the purpose is not here to provide a detailed condition report as one would produce ahead of conservation works, the aim being very different.

The alterations entered on Excel are enriched with photographs, classified, after each condition report day, by inventory number, room, or alteration cause. They are essential during the data treatment phase in order to check for possible cause interpretation mistakes and to illustrate the diagnosis report.

Stages 4 et 5. Diagnosis and recommendations[14]

> Time: 5 days for one person.
> Equipment: computer with 2016 Excel software, modelled Excel spreadsheet, alteration photographs taken from the condition report phase.
> Results: cause assessments and recommendations based on the whole collection; ranking by increasing importance of 14 generic alteration causes identified for historic houses; 4 collection alteration levels ; detail of specific alteration causes and diagnoses for each of the 14 generic causes assessed.

Stage 4 general description

The Excel data-treatment software makes it possible to create dynamic cross-sectional graphs in two specifics tabs (Alteration causes/diagnosis synthesis and Alterations synthesis). These charts collect data entered in the Condition report form tab automatically (see **fig. 9**). Their creation relies on the number, typology, and extent of found alterations as well as the causes and diagnoses identify during the report phase.

The fundamental element of the calculation system is the extent of alterations to which causes and diagnoses are associated (alteration extent = severity index × extent index).

Although Excel makes it possible to create a potentially infinite number of charts, our aim is to supply evaluators with an automatized, user-friendly data-treatment system so as to not be unnecessarily time-consuming, preferring instead to focus on interpreting the assessment results. So as to keep things synthetic and simple, the number of graphs available to the evaluator is predetermined (Alterations, Causes, Diagnosis) but their dynamic tabs make it possible to cross-reference, by collection, cause (etc.) typology, and to display graphic representations automatically. These representations (painting alteration causes, for instance), are truly useful during discussions with different heads of collections. Each chart also comes with alteration findings and photographs, which help to make our diagnoses and recommendations clearer, measurable, and scientifically sound.

Some examples of automated charts:
- impact of causes: chart the recurrence of causes, detailing the extent of resulting alterations (**fig. 11** and **12**);
- impact of causes: charts the recurrence of alteration causes based on collections' sensitivity to the 14 historic-house specific alteration causes. The calculation system is detailed in **figure 13;**
- specific causes: specific cause chart for the first 3 generic causes. According to Pareto's principle and statistic risk studies, 20% of causes (hence 3 in 14) would suffice to account for 80% of effects/alterations on collections (**fig. 14** et **15**);
- diagnosis: these charts plot diagnoses for the first 3 generic causes (**fig. 16**, **18**, **20**);
- recommendations: examples of recommendations resulting from the diagnosis for the first three generic alteration causes **(fig. 17**, **19**, **21**).

Assessment results

The three generic alteration causes with the greatest impact on collection and décor preventive conservation are mostly related to the impact of climate and the natural aging of materials, handling,

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[14] Time needed for an experienced Excel user on a non-modelled spreadsheet. Following the application of the method at the Château de Maintenon, the spreadsheet calculations were automated, thus reducing data treatment from 5 to 1 day.

as well as light, which affects a small number of objects but with a major alteration intensity(see **fig. 11**).

The specific causes analysis provides us with important details about the factors which will require priority measures from collection managers (see **fig. 14**): for example, the specific causes for the « handling/transport/accident » factor are, in most cases, related to rubbing due to the flow of visitors, and to occasional shocks. The diagnosis (see **fig. 18**) shows margins of improvement for the frequency of handling, and for the close protection of works during exceptional events held at the château.

Recommendations arising from this diagnosis (see **fig. 19**) thus aim to improve object-handling protocols in the short team in order to improve event planners' awareness, limit accidents, and review the mechanical protection system for the most sensitive artworks.

The method's results have made it possible to identify sometimes unexpected aspects of preventive conservation clearly. For instance, the alteration and room climate survey made it possible to identify any humidity risk due to the presence of water in the castle moats. Contrary to what an intuition-based diagnosis might conclude, the presence of water here does not constitute a risk but instead contributes to maintaining a relatively appropriate relative humidity rate (> 40 % RH), compensating during drought periods which are heightened by the heating system. The corresponding diagnosis (see **fig. 16**)in fact reveals that fluctuations in the RH are due to the building's nature and that simple measures can be carried out in the short term, at a reasonable cost (see **fig. 17**).

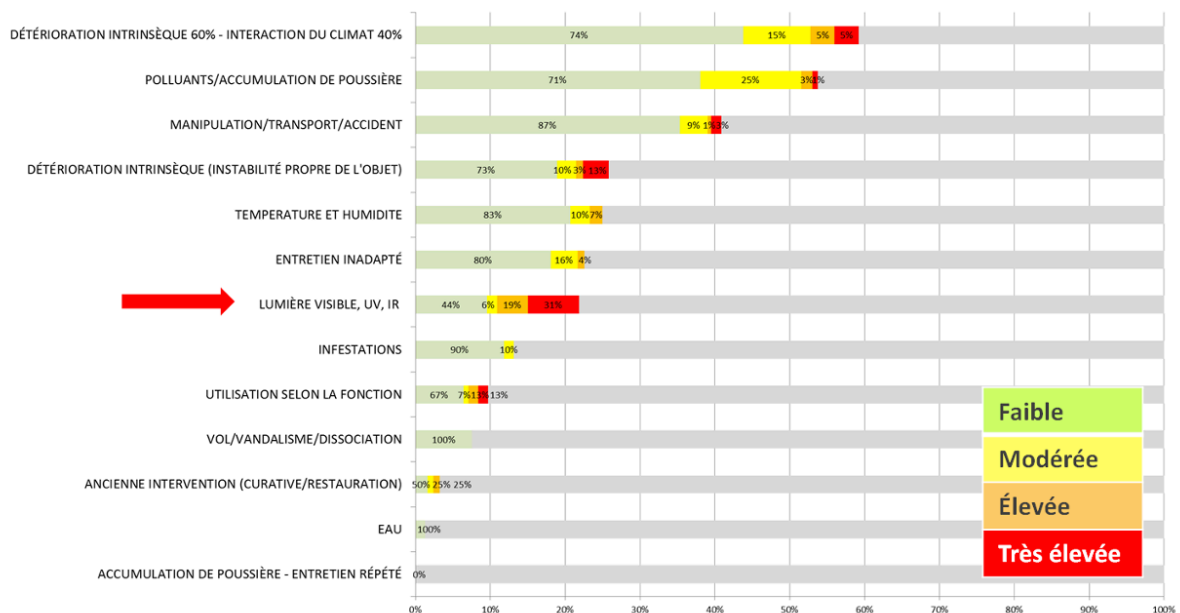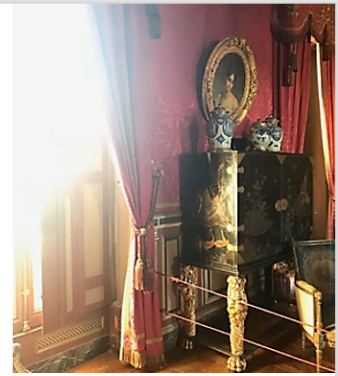# 4 RESULTS – ALTERATION CAUSES IMPACT

Figure 11 Assessment results: the impact of alteration causes. This chart plots the recurrence of alteration causes based on the sensitivity materials in the objects (histogram). The number of causes, 14 altogether, is predetermined. Their ranking in the chart is generated automatically, depending on the alteration causes entered in the Excel drop-down menu during the condition-report phase. © EPICO team, Château de Versailles.
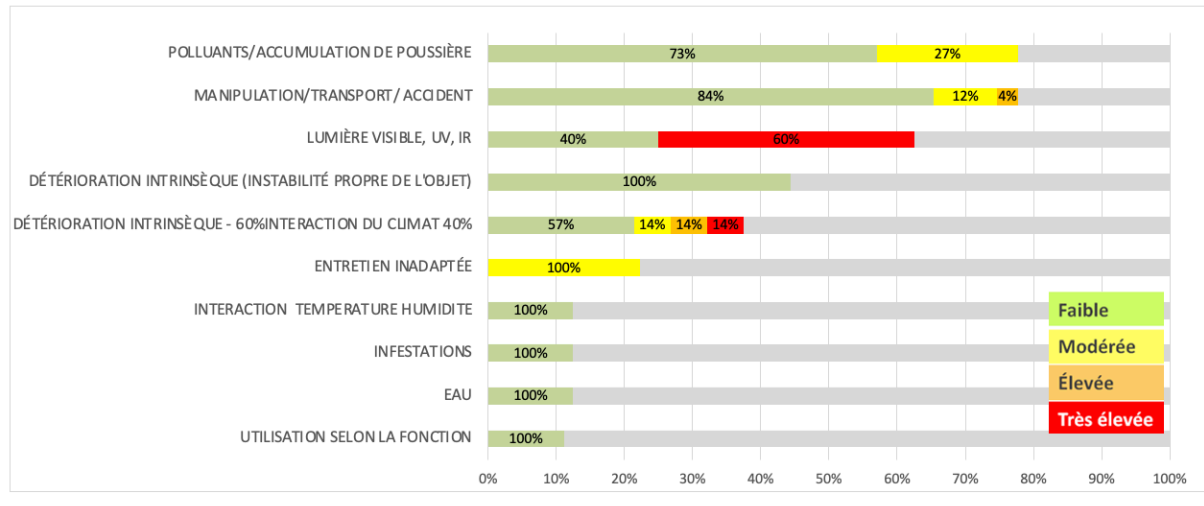
Figure 12 Assessment results: impact of causes with a zone/specifc room. © EPICO team , Château de Versailles

4
IMPACT OF CAUSES CALCULATION SYSTEM

L'IMPACT ASSESSMENT = $\sum_{i=1}^{n}$ **(** *Affected objects + extent of alterations)*

CAUSE RECURRENCE

23 % of objects from the total collection from the room (100 %) likely to be altered display alterations generated by the climate cause
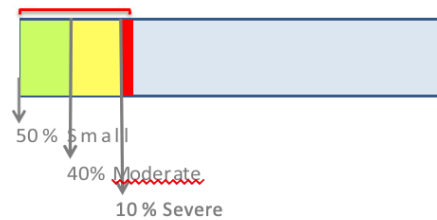
23 % of collection   LEVEL1

7 objects altered / 30 likely out of 33 objects in total within the room

+

EXTENT OF ALTERATIONS

For the 23 % of the room collection
- 50 % of reported causes generated small alterations
- 40 % of reported causes generated moderate alterations
- 10 % of reported causes generated severe alteration

LEVEL 2

50 % Small

40% Moderate

10 % Severe

Figure 13 Impact of causes calculation system. © EPICO team, Château de Versailles.

4
RESULTS-SPECIFIC CAUSES

INTRINSIC DETERIORATION 60%
CLIMATE INTERACTION 40%

18%

9%

7%

5%

14%

2%

45%

- RH Fluctuations $(\Delta\ 24h > 15\%)$
- Low stable RH (< 40%)
- High stable RH (> 70%)
- High temperature (> 25°C)
- Unstable materials
- Production method
- Natural aging of object materials
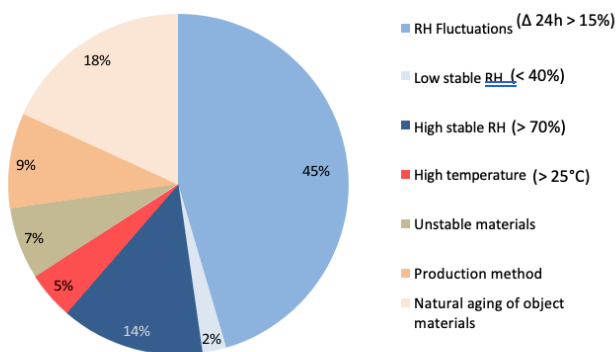
RH FLUCTUATION
(heating regulation)

GRAND SALON

Figure 14 Assessment results: details of specific causes for intrinsic deterioration – climate interaction generic cause. © EPICO team, Château de Versailles.
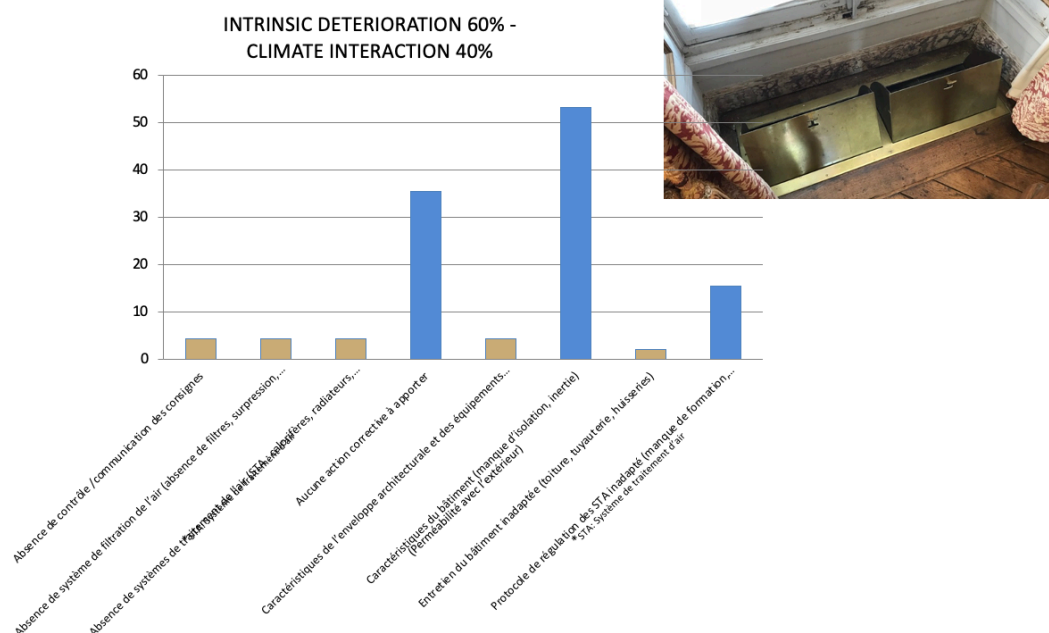
5
CAUSES DIAGNOSIS

Figure 16 Assessment results : intrinsic deterioration – climate interation cause diagnosis. © EPICO team, Château de Versailles.

5
RECOMMENDATIONS
Intrinsic deterioration 60% -climate interaction 40%

Recommendations	Time frame/ budget
Purchase 6 electronic thermo-hydrographers for T.C° and RH% control, and one recording luxmeter, TESTO brand	Short-term 0-2 years Cost : 1.000€
Establish an air-regulation protocol: shut the flaps to 45° in winter, install radiator-covers, close the shutters on the south and west sides from 12.00 to 20.00 in summertime, close east-side shutters in the morning	Short-term 0-2 years Cost : 500€
Building enveloppe: Plan refurbishment for doors, windows, and Grande Galerie shutters	Medium-term 2-5 years On-going
Carry on with roof refurbishment, started in 2015	Long-term 5-10 years On-goings
Restore and cover window pelmets in the Grande Galerie	Short team 0-2 years Cost to be determined

Figure 17 Assessment results: recommendations for the intrinsic deterioration – climate interaction cause. © EPICO team, Château de Versailles.
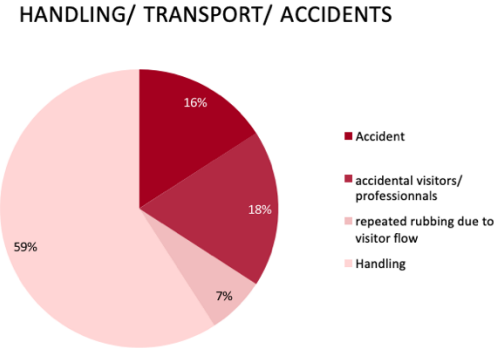
Figure 15 Assessment results: details of specific causes for generic handling/transport.accidents cause.
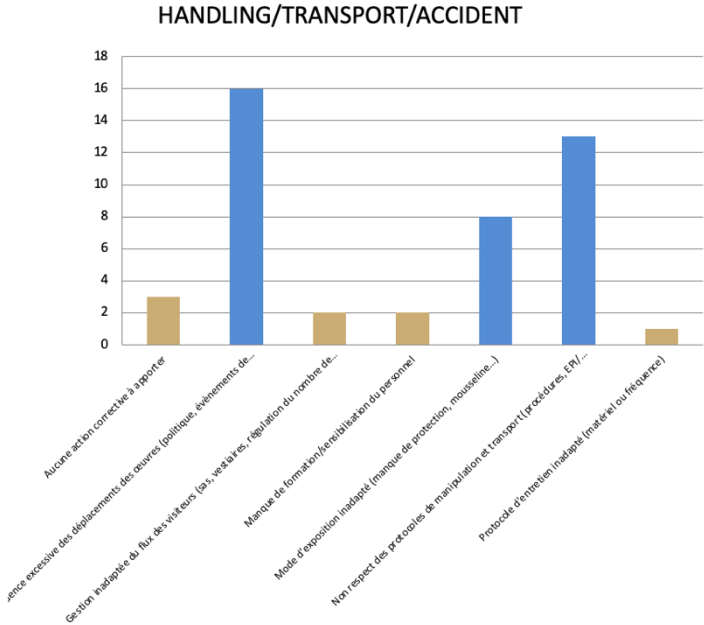© EPICO team, Château de Versailles.

Figure 18 Assessment resutls: diagnosis of the handling/ transport/ accidents cause.
© EPICO team, Château de Versailles.

5 RECOMMENDATIONS

Handling / transport / accidents

Recommendations	Time frame/ budget
Restrict and control handling, with stricter procedure	Short-term 0-2 years Cost : 0€
Provide preventive conservation training for the Château team, in connection with the many contractors	Short-term 0-2 years Cost : 0€
Pay increased attention to safety and security for some rooms	Short-term 0-2 years Cost : < 1.000€
Set up protection system for immovable leather and wallpaper décor. Consider restoring (preliminary study)	Medium term 2-5 years Cost : < 10.000€

Figure 19 Assessment results : recommendations for handling/ transport/ accidents cause.
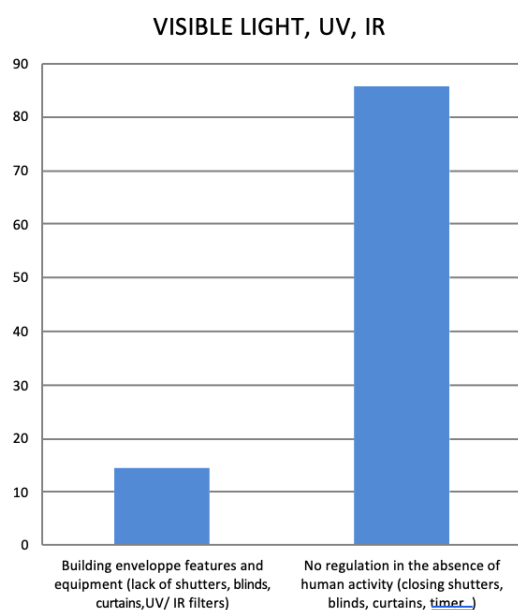© EPICO Team, Château de Versailles.

5 CAUSES DIAGNOSIS

Figure 20 Assessment results: diagnosis of visible light/ UV/ IR cause. © EPICO team, Château de Versailles.

5 RECOMMENDATIONS

Visible light, UV, IR

Recommendations	Time frame/ budget
Apply UV and IR film to windows	Short-term 0-2 years Cost: < XXX €
Restore and cover window pelmets in Grande Galerie	Short-term 0-2 years Cost: < XXX €
Systemize upkeep best practices, with additional closing of south and west-side shutters, in summertime, from 12.00 to 20.00, and east-side in the morning	Short-term 0-2 years Cost: < XXX €
Replace lighting system –halogen lamps and fluorescent tubs (scenographer's advice)	Short-term 0-2 years Cost: < 2000 €

Figure 21 Assessment results: recommendations for visible light/ UV/ IR cause.
© EPICO team, Château de Versailles.

Limitations and future perspectives for the EPICO method

About technique

This new application of the EPICO method has enabled the research team to introduce technical improvements and made the method easier to share. First of all, the zoning calculation is improved, notably by creating an add-on factor that can be applied when a room is closed to the public but opens on a high-footfall area. A cartography of human impact and orientation is supplied, on top of zoning, which gathers five criteria (human impact, orientation, museography, visit and activity types). The Excel condition report form has been made more user-friendly by restricting choices for specific causes and diagnoses based on the generic causes selected previously. Some terms have been revised in order to make them clearer. Finally, the automation of graphic and calculation representations has been finalised.

The research programme scientific committee proses to highlight positive points regarding collection management with diagnosis graphs: the lowest scores for alteration causes often represent the best-managed aspects in terms of conservation conditions, thanks to the staff's commitment. How can we emphasize this dedication? In what condition would the collection be without this upkeep? Is it possible to express this damage delay factor in terms of gain or loss percentages? Managing the impact of collection management of the state of conservation could be the next stage in this research.

Valorizing the programme

Members of the scientific committee have drawn attention to the EPICO method's innovative aspects. It provides a high-performing, unified tool for preserving historic monument collections, which are seldom considered.

The EPICO programme's sustainability relies on a new challenge for the research team: sharing the method through the tools established for this new phase of the programme (website, training for professionals and students, partnerships with international heritage organisations). The financial aspect also requires particular attention, as the programme is self-funded by partner institutions. Financial contributions will rely on valorizing the savings that can be made thanks to the method, which involves a relatively small initial investment; this can nevertheless be difficult to justify to administrations.

It would be worth exploring sponsorship opportunities: results from the 2017 international symposium hosted at the Château de Versailles were very positive and show it is possible to appeal to patrons' enthusiasm and raise funds for preventive conservation. In this respect, our British colleagues (starting with the National Trust) teach us that communication with the public helps to raise awareness of the need to preserve heritage as well as to allocate resources to it.

Conclusion

The partnership between the Châteaux of Versailles and Maintenon was a success for both institutions. The assessment results were shared with representatives from the département Council, which is in charge of funding, and future scientific and cultural projects for the estate. The representatives welcomed the Maintenon team's recommendations.

Meanwhile, the presence of exceptional works, some of which had not been moved in over a century, was a unique opportunity for the Versailles team, who sought to improve the method by putting it through a new test in order to see which aspects needed changing. The improvement and research process is still ongoing for the EPICO method, including by applying it to the collections of the Château de Versailles.

Following these first experiments, we find that the method is effective, not only in terms of presenting quantitative results simply but also for its ability to connect the different preventive conservation interlocutors within a palace/house and to guide them in their understanding of problems and search for solutions.

Thanks

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Authors

Danilo Forleo Danilo Forleo holds a degree in cultural heritage management and specializes in preventive conservation. He joined the the collection registrar team for the Château de Versailles in 2011. In 2015, he was put in charge of collection preventive conservation, in the context important restoration works on the Palace. Since 2013, he has carried out preventive conservation research, proposing innovative solutions to preserve historic house collections (Multimedial alteration database, Climate graphing software projects). He founded the EPICO research programme in 2015 and has lead it since then.
Preventive conservation officer, EPICO research programme project manager, Etablissement public du château de Versailles, 1 rue de l'Indépendance américaine, 78000, Versailles, danilo.forleo@chateauversailles.fr
Nadia Francaviglia Nadia Francaviglia is a conservator-restorer of cultural heritage and specialises in heritage preventive conservation. She has freelanced in several French museums, among which the Château de Versailles, the Louvre Museum and the Louvre-Lens. Since 2014, she has taken part in the EPICO programme, European protocol In preventive conservation, led by the Château de Versailles.
Conservator and preventive conservation adviser, research associate for the EPICO programme, nadia.francaviglia@gmail.com