

3D and horological heritage: Chronospedia's narrative of the preservation of horology's know-how — a dissenting voice (Preliminary draft)

Denis Roegel*

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1 Introduction

The Chronospedia project is a recent project by the clock restorer François Simon (called Simon-Fustier) and the physicist Konstantin Protasov (КОНСТАНТИН ПРОТАСОВ), both French citizens. This project focuses on the 3D modeling of clocks (not watches) and has especially expanded since 2020. After a summary of the utility of 3D technologies for horology, this note describes the origins of the Chronospedia project, its changing aims and current narrative, its utility, its real

*I am an independent researcher in the history of science, and in particular in the history of mathematics and technology. I am co-author of *A general history of horology* (Oxford University Press, 2022), where I wrote about 19th and 20th century astronomical clocks. I have recently published several articles in *Antiquarian Horology*, as well as a book on the 16th century paintings on the Strasbourg astronomical clock. I have also examined about a thousand tower clocks, mostly in France, and in particular all the tower clocks in Paris. I have also been active in 3D modeling and teaching, and I have worked on the 3D modeling of astronomical clocks as early as 2001. More recently, I have created a 3D model for the destroyed clock at the Notre-Dame cathedral in Paris. The model is online since 2020, I have also made a number of animations on *youtube*, I made a mobile application for Android, I had the clock printed in 3D in 2021, and in 2022 I also experimented with Augmented Reality using a Microsoft HoloLens headset. On the professional side, I happen to be assistant professor in computer science, and there is therefore some overlap between my professional and independent interests. The opinions presented here are however my own, and are of no concern to my employers.

motivations as well as its current state and future. This seems necessary given a number of incorrect statements that have been made in various places, and given the appeal that the 3D technology and AI may have to those who are perhaps not familiar with these technologies or with the priorities of horology conservation. My background both in the study and preservation of horological heritage, and my long experience on technical 3D development leads me to give a very critical assessment of the Chronospedia project.

2 3D and horology

In this section, I want to give a thorough overview of the utility of 3D for horology, because this is an intricate and confuse matter that needs to be clarified. But first, I would like to give some details about my own experience in 3D and horology.

2.1 My background

The subject of 3D has been of interest to me since the 1990s, and even before. In the 1980s, for example, I dealt with the representation of 3D wire objects seen through a glass sphere. Even earlier than that, I wrote a simple 3D N-body simulation. Being a computer scientist, I have always had a computing approach to 3D, and never a simple “software user” approach, such as is common in 3D modeling. I have actually had classes on 3D in the 1980s, and have myself taught 3D programming in the early 2000s. I have in fact done many 3D experiments during the past 25 years, and back in 2001 I worked for instance on modeling parts of the Strasbourg astronomical clock in 3D. More recently, in 2020, I made a 3D model of the 19th century mechanical clock of the Notre Dame Cathedral in Paris. Although the clock itself was destroyed in 2019, a model could be made thanks to measurements and photographs I had taken in 2016 when I was surveying all of Paris’ tower clocks. The 3D model was put online in the form of open files (in particular in the STEP format), one per part, supplemented by a file giving the locations of the parts (each part has its own reference frame)¹. In addition, in 2021 I also created animations², an Android interactive application [7]³ and had a 1/3 scale model made by 3D printing⁴. And in 2022 I made experiments in Augmented Reality (AR) with a Microsoft Hololens headset [4]. It was then possible

¹<https://github.com/roegeld/notredame>

²<https://www.youtube.com/@horlogenotredame>

³The application was on the Google PlayStore between 2021 and 2024, but is now only available from <https://roegeld.github.io/apk/notre-dame-clock-0.9.apk>

⁴See the media coverage at <https://www.estrepublicain.fr/education/2021/04/11/l-iut-charlemagne-reconstitue-l-horloge-de-notre-dame>

to move around a virtual Notre-Dame clock.

Since I also work on the survey and documentation of scientific and technical heritage, I am both on the technical side of 3D and on the side of its possible use. This background enables me to ask a number of questions or to point out problems linked to 3D, problems of which curators and other persons involved in heritage preservation are not necessarily aware because they only see 3D from the point of view of its use as a mediation tool (viz., 3D can be used to make heritage more attractive and to bring more audiences to the works, by making them less austere).

2.2 The usefulness of 3D in general

3D modeling can be useful to make an object accessible to a large number of people, especially when the actual object is not easily accessible, or when the internal structure is partially or entirely hidden. A 3D model may therefore enable the study of an object, it can provide a glimpse of its structure, and it can make it possible to reconstruct virtually an object that does no longer exists. It can also enable its physical construction, or its insertion into some navigable space, and so on. There are clearly many uses of 3D and most, if not all, of these uses are perfectly legitimate. When these applications of 3D are considered in isolation, it is quite clear that the usefulness of 3D is hard to question.

However, one also needs to have a broader perspective, and not only look at the system made by an object and the corresponding 3D model, because this system evolves in a much broader ecosystem. For instance, one might consider that glyphosate is very useful against weed, but if one takes the entire ecosystem, it appears that glyphosate is not such a miraculous product and has detrimental effects on animals. The same is true for 3D. There are positive sides and there are negative sides to the use of 3D.

2.3 The usefulness of 3D for horological heritage

We must first realize that watch and clock mechanisms mostly have wheels with parallel axes (this is the case for almost all watches) and that therefore 2D plans are usually sufficient. 3D models only add a marginal contribution, and for that very reason, the models are much easier to design than in the general case. Most 3D modeling is merely about adding some thickness to a 2D contour. 3D is actually rarely absolutely necessary, especially for watchmakers. It is neither absolutely necessary to design a clock or watch, nor is it absolutely necessary to study such a clock or watch.

At this point, we must clearly distinguish the 3D technology which is used to create a mechanism from the 3D technology which is used to explain it. These are two different things, because understanding a mechanism does in general not

require going into all the technical details. Someone who wants to understand a mechanism usually does not seek to have all the plans, doesn't need to know the manufacturing tolerances, the materials used, etc. But the design of a watch or clock also does not absolutely require 3D. It is true that 3D can be useful for the design of certain very specific mechanisms where 2D is insufficient (this is also true for buildings, just think of those of Frank Gehry), this does only rarely apply to the context of this discussion, especially if we only consider heritage clocks or watches. But of course, a 3D model can be useful for manufacture, for instance using a CNC machine.

The 3D technology is also interesting by itself, in that there may be technical challenges in the design itself, which do not arise in the actual constructions. For instance, some actual parts may be moulded, but the 3D models may have to approximate the moulds, especially when these moulds cannot be 3D scanned.

We can, by the way, wonder whether the model I made of the clock of Notre-Dame cathedral in Paris was useful and whether it was used. It turns out that a number of Russians used it⁵ and that the Diderot high school in Paris certainly also used it when their students made a partial (?) model of a clock similar to the Notre-Dame clock as part of a project to reconstruct that clock. But the students of the Diderot high school never contacted me and I do not know the details of their project⁶. A few isolated 3D enthusiasts have also used my model. That been said, there can't have been many of them, because using my model requires knowing how to import STEP files and how to apply translations to them dependin on the parts, and few so-called 3D "expert" know how to do that. My Android application has probably also been used a little bit. In summary, my 3D model generated a little bit of interest around the time of the second anniversary of the Notre-Dame fire, but that interest quickly dried up.

Likewise, we can wonder if the achievements made by others, for example in Cluses⁷ or Mafra⁸, were really useful. I am taking these examples from the Chronospedia project, as Chronospedia is the main example of such models. I will come back to that later, but for now, we may wonder whether these models helped anyone to learn something? As far as I am concerned, I do not believe that the model of the clock of the town hall of Cluses has allowed anyone, including

⁵See for instance at <https://raketa.com/w/news/sgorevshie-chasy-sobora-notr-dam-pomozhet-vosstanovit-raketa> where a Russian engineer is studying my 3D model. They never contacted me and I am not even sure that they know that I authored the model! It was also shown on the TV channel Mir24.

⁶In fact, the persons in charge of the clock being modeled have even denied my request to access that clock, although I had examined it when it was in the church.

⁷See https://www.youtube.com/watch?v=VWhWY_mzzEc and the viewer <http://poncet.horlogerie-ancienne.fr>

⁸See the viewers at <http://mafra.horlogerie-ancienne.fr/partie-4> and <http://mafra.horlogerie-ancienne.fr/SUD-demontage>



Figure 1: The clock 3D printed in 2021.

the town hall employees of Cluses and of the Cluses museum, to really understand how that clock works. In fact, of all the models I have seen, I didn't find anyone really useful and none has really allowed me to explore the clocks, get information about the parts, the numbers of teeth, the dimensions, etc. It is perhaps only when one has the model at hand, for instance in SolidWorks, that one can currently access all the information that should be accessed. This is something that only few people can do nowadays. In addition to these technical hindrances, models like those of the Mafra clocks do not seem to have been widely advertised. 3D viewers are only found accidentally. Even the "disassembly tutorials" made from the models are of limited interest. One doesn't need to be a clockworker to know how to dismantle a turret clock. The only things that are needed are some minimal intelligence and organization. This will be more than enough! It is therefore far from convincing that the 3D modeling carried out so far demonstrate the necessity of 3D!

It should be noted that certain 3D creations, for example those of the clocks at Vaux-le-Vicomte⁹, Mafra, and others, have not even really been made public, at least as of 2024. The clocks of Mafra can be explored online, but pretty poorly. It is quite tedious to extract the number of teeth on the two models (in particular for the large wheels of the carillon cylinders), in part because the interface does not give this information and it is not possible to display a part in isolation. The models are also rather approximate (even false in places) and even incomplete as far as the cylinders of the carillons are concerned. The details can be seen in the documentation¹⁰ I created from screenshots of the viewers. The technical

⁹<https://www.youtube.com/watch?v=G7PTr3ogjM0>

¹⁰<https://horloges.github.io/mafra/nord.html>

characteristics of these clocks have also not been made public in a report, although they are very interesting (for example for disengagements, or simply for chimes with a counting wheel of 57 teeth = $(1 + 2 + 3) \times 6 + (1 + 2 + 3 + 4 + 5 + 6)$ on the North Tower clock, or in relation to the time display, also on the North Tower). The public can therefore not really manipulate the objects and researchers cannot independently develop the models created. Apart from the “public” examples cited above, we can still point out that certain horologists create models, but for internal use, for their “pleasure” one could say, and these models do not lead to animations or renderings for customers.

Is 3D useful for repairs? It’s not that certain either. For example, it is in general not necessary to model an entire clock in order to reconstruct a single missing part (for example a count wheel). And if a part breaks, the broken part can most of the time be used to make another one. Modeling an entire clock in order to be able to repair one piece is in fact not very efficient. Furthermore, clocks are all a little different and the complete modeling of one clock will generally not be very useful for another. It may be necessary to make a new model from scratch each time.

Much has been claimed about the benefits of 3D. In a conference given in 2020, Marc Malotiaux, an advisor to the Lyon Chamber of Commerce and Industry, in charge of the Living Heritage Company label, said for example that “[François Simon-Fustier] succeeded in reconstructing a 17th century clock thanks to the *Encyclopédie* of d’Alembert and Diderot, using the 3D technique with a young person”. This is quite gibberish! The *Encyclopédie* of Diderot and d’Alembert contains approximate plans (and this is perfectly normal, almost all published or unpublished plans are approximate) of a clock, not from the 17th century, but from the 18th century, and these plans have been adapted by Simon-Fustier’s team so that the clock could work (and there was not a unique way to do so). It was not the 3D technology that made the reconstruction possible, it was merely rational thought. 3D only made it possible to visualize the reconstruction. There is something here that should invite us to reflect, namely that certain people who have decision-making power for titles, diplomas, etc., are led to evaluate work that they do not in fact totally understand.

Is 3D useful for teaching? There is indeed a certain utility of 3D modeling for teaching purposes, for example in the case of complex mechanisms like striking watches, although 2D is in fact more than sufficient. In fact, in certain cases, understanding a mechanism requires a focus on only the essential parts, and it is important to restrict the explanations to the bare bones. When 3D is employed, there may in fact be too much unnecessary information in a scene, which can go against the proper aims of teaching. In any case, the necessity of 3D for tower clocks is relatively limited. Furthermore, a horologist, or even a non-horologist, can easily understand how a tower clock works without the help of 3D. Likewise, as I said above in the case of the Mafra clocks, 3D has little utility for knowing

how to dismantle a tower clock. I consider that it is more important to be able to think than to know how to use a 3D model, which, in most cases, will not exactly be the right one.

That being said, the question of teaching refers to pedagogy and the 3D model is not to be identified with the pedagogy of this model. A 3D model can be well done, and poorly explained. And conversely, we could have good pedagogy on a bad model. Finally, pedagogy refers to the public. Different audiences have different needs and these needs should be taken into account.

The truth is that today 3D in horology is often more a spectacle than a real educational tool. Take for instance the case of the movie shown since 2017 next to the astronomical clock of Strasbourg Cathedral. This movie hardly makes it possible to really understand the clock, even if one watches it several times. At best it gives a good idea of the layout of the gearworks. It does not replace real scientific documentation and moreover this movie contains numerous scientific errors, which makes it of very limited interest for researchers. It is, however, a beautiful spectacle which amazes tourists (and which cost more than 40,000 euros). We should therefore not confuse a real educational tool with a demonstration of the possibilities of 3D. Those are two different things. Teaching is not simply about impressing, although it is also about leaving a memory. And a memory is not the same thing as knowledge or understanding.

For the record, 3D has been used for a long time in horology, including for tower clocks, and in terms of beautiful creations in augmented reality, we can cite the excellent work of John Redfern (1939-2019) with Autodesk 3ds Max¹¹. This work goes far beyond what some achieve today with other commercial tools. We could also cite the beautiful recent educational animations by Bartosz Ciechanowski for watches¹². These animations do precisely prove that explaining mechanisms is much more than simply knowing how to use softwares like SolidWorks. Furthermore, it turns out that SolidWorks was used to model tower clocks as early as 2012 or earlier.¹³ And by searching a little bit more, we discover that there was a beautiful work of modeling the clock of the cathedral of León in Spain already in 1994 and this is undoubtedly not the first 3D modeling of a tower clock. Those who now claim to have been the first to apply 3D to tower clocks are therefore mistaken. On the other hand, they may be the first ones to try to profit economically from it.

¹¹See <https://redfernanimation.com/animations>

¹²See <https://ciechanow.ski/mechanical-watch>

¹³See for example the work of López-García, Dávila-Rufián and Dorado-Vicente.

2.4 The 3D model as opposed to interactive videos or animations

It is important to understand what 3D design is and to understand it in abstraction from any particular software. A complex mechanism is made up of several parts. These parts are located in space in different places, possibly varying over time, but each part can be considered in its own reference frame. For example, a wheel naturally has an axis of rotation and we can introduce a particular point on this axis. A particular part is made up of flat or curved surfaces whose intersections determine the object. These different surfaces are constructed on the basis of reference points positioned in space or certain dimensions. For example, if we construct a cylindrical shaft, we can introduce the extreme points of the axis of the shaft and the radius of the cylinder. These will be the parameters of the object.

A 3D model is therefore a set of objects, themselves determined by points and dimensions. These points and dimensions are generally placed interactively with software such as CATIA, Autodesk Inventor, SolidWorks, etc., but nothing prevents us from directly creating more abstract representations by other means. For example, a cube can be created directly in the OBJ format, even if it is generally more tedious to do so than using an interactive tool which has a library of fundamental objects.

If a model has flexible parts, the previous approach is however not fully applicable, and one must either consider creating a series of variations of an object, or limit yourself to animation within the software considered.

An example of an online 3D model is the one I made for the Notre-Dame clock¹⁴. It simply consists of many STEP files as well as other files, in addition to a file indicating where the different objects are located in space in a reference state. Such STEP files can be created by most modeling software. And it is from a 3D model that animations can be created. In other words, the individual objects can be put in motion, videos can be created, also applications on mobile devices, etc.¹⁵ But all these applications should not be confused with the model itself and if the model is not made accessible, most scientific developments of the model become impossible.

However, even if a model is made accessible in a format such as STEP, it still remains a rigid model and it is not easy to modify it. To be able to modify a model, one generally needs to be able to return to the original format, in order

¹⁴<https://github.com/roegeld/notredame>

¹⁵It should be noted that without the organization of the model in exchange formats, it would not have been possible for me to carry out all the applications which made use of several different software programs. Using an exchange format and splitting the model into openly accessible individual elements opens up possibilities for considerable extensions which are not possible with any proprietary format.

to move points, change dimensions, etc. This often requires access to the modeling software that was used to create the model. Furthermore, there are different design methods, and designing a model is not only done by transcribing dimensions measured on a clock into software. The question of access to design data is therefore a lot more complex than it seems at first glance. For comparison, we can take the case of car design. A car is a mechanism made up of parts. The person who buys a car can drive it, but he/she can also, if he/she wishes, dismantle the car, replace one part with another, examine any part, possibly have a particular part redone or improved, etc. He/she may possibly have access to certain manufacturer plans, but he/she will not have access to a most internal data of the manufacturer, such as certain of its plans, or the machines and factories which were used in the manufacturing. Nor will he/she have access to everything that led to the design, the exchanges, the choices, which may very well have disappeared from the final plans. We must also understand that a manufacturer wants to protect its activity. Similarly, those who create a 3D model also have the right to protect their creative activity, whatever form this activity takes. However, this creation activity is located both upstream of the model (and allows the model to be modified) and downstream of the model (and allows the use of the model to be modified). Knowing that many designers move on to another model once the one is completed, it is good for users to have control over the model, in order to possibly create other uses for it than those intended by the designer. This is the whole point of communicating 3D models.

2.5 Different types of models and different qualities of models

3D modeling is not a binary business. We do not have modeled objects on one side and objects that are not modeled on the other. We have a whole gradation, with the possibility of having objects incompletely modeled, or poorly modeled, sometimes with deliberate simplifications, sometimes with errors unknown to the designers.

2.6 The access to 3D models and the access formats

A small business cannot do everything, and cannot take care of all the models it has created. Even a car manufacturer ends up discontinuing the support for older models. To do useful work, the best is to make the models publicly accessible and without discrimination. This means that everyone, without restrictions and without having to ask, should have a complete access to a model. In this way, the models can be usefully developed, without this access representing a burden for the company which made the model, or even without a cost for an administration.

Many heritage developments can in fact be done on voluntary basis, but those who could do so must be given the means to do so.

If a 3D model is not accessible, or if only interactive videos or animations are provided, it is almost impossible to go beyond what has been provided. If, for example, the animations do not make it possible to hide certain parts, then one will have to live with it. If the animations do not allow one to have the dimensions of the parts, one will have to live with it. On the other hand, if the model is provided, new possibilities open up. For these possibilities to be greatest, the model must be complete and usable in as many software programs as possible. One obviously should not have to buy software to use the model. All this requires that the model be made available in an exchange format, or even in several exchange formats. It seems that one of the common denominators is the STEP format, but we can add to it (and not substitute) formats like OBJ, STL, etc. The OBJ format is a mesh format, so it is already degraded, but it is useful for some applications. It is also essential to provide the elements of the model (wheels, shafts, etc.) each in their natural reference frame (for example with the origin of a wheel on its axis and the axis of rotation along one of the three axes reference), which in turn requires providing positioning data for the parts in space. It is in all cases essential to avoid providing only a proprietary format, such as that of SolidWorks, which would require having this software, or being able to import this format, which is not always possible, because each software can only import certain formats.

A model must be accessible in the form of its elements, and not in the form of a rigid block. I could have made only one STEP file accessible for the clock of Notre-Dame of Paris¹⁶, but that would not have facilitated animations by other people. (Even though no one other than me and my students seem to have made animations based on my model, this possibility exists.)

It would actually be even better to provide the dimensions that are the basis for creating the models. Contrary to what some people say or think (such as the instigator of the Vaux-le-Vicomte, Cluses, Mafra, etc.) models, *the dimensions noted are not necessarily explicitly present in a model*. There may very well have been prior processing of the data before their integration into software. If someone models, for example, a regular octahedron, this modeling will perhaps have been carried out from the radius of the sphere in which the octahedron is inscribed, but this radius may not be present in the model, if the model merely includes the coordinates of the six vertices.

We can observe that the 3D models of the clocks modeled in 3D have practically never been provided, and even less the measurements themselves. In fact, the only case that I know of is that of the Notre-Dame of Paris clock, but I have also not provided the details of the measurements, nor the original photographs

¹⁶<https://github.com/roegeld/notredame>

(perhaps I will do so one day). The models of the clocks of Vaux-le-Vicomte, Cluses, Mafra, etc., were not provided, neither to the public, nor even to the owners of these models. Technical details have also not been made public.¹⁷ However, nothing prevents other designers from making their models available in the same form. In Vaux-le-Vicomte, Cluses, Mafra, etc., the author of the model should (and could) prepare individual files for each part (with portable and logical names!), as well as a localization file, so that these parts can be reassembled in another software, without having access to only a monolithic model.

2.7 The usefulness of a mechanical library

One can indeed contemplate creating a library of mechanisms, like Chronospedia but it will only be really interesting if the models themselves are made accessible (freely and to all, without any discrimination), which is not at all guaranteed.¹⁸ A catalog of videos or interactive animations is not an *open* library of mechanisms. And a paid catalog, or accessible only by registration (even free), is not an open library.

The creation of a library would therefore benefit considerably from the openness of models, and in particular from the use of an exchange format, because this would allow different people, using different kinds of software, to contribute to this library. It is quite curious to see that until recently the project mentioned above only contemplated a single person and a single software to create this library [9, p. 124], while the possibilities are in fact almost infinite, and that the modeling know-how is not at all tied to horology. Modeling clocks like those of Mafra, Cluses, Vaux-le-Vicomte, etc., requires almost no specifically horological knowledge, and the little knowledge required can be easily acquired without the help of horologist. *A horologist, in most cases, knows for instance nothing about the theories of the bending of suspension blades, or about gear profiles.* He/she knows that there are different profiles, but his/her knowledge is often limited to the use of wheel cutters that he/she has purchased or collected. Probably only a tiny minority of clock restorers would know how to create *ex nihilo* cutters for, say, epicycloid profiles.

A fundamental, but often forgotten, argument for the openness of models is

¹⁷Note that it is quite curious that the instigator of these models wants to develop a free horology encyclopedia, while at the same time refusing to make the restoration reports of his own interventions accessible, as well as the photographs of his intervention in Cluses, while parts of a report on a barograph have been improperly occulted, etc., and therefore that there is basically a lot of discrimination, an approach far removed from the encyclopedism and openness supposedly advocated.

¹⁸As of June 2024, Chronospedia still does not make any models freely accessible. The Chronospedia site¹⁹ does not include any downloadable models.

the fact that it provides greater robustness to a project. Currently Simon-Fustier's project relies on only a few people, notably his employee S. Lucchetti and a few others. On the other hand, if the models are open, a larger number of people can contribute and exchange, and this naturally results in greater robustness. The project is then neither based on a single person, nor on a single software, nor even on a single theme. The very concept of horological mechanisms is difficult to define, and we need bridges with mechanisms in general, and with all those who can contribute something, horology being only one aspect among others of the subjects that can be handled.

On the other hand, it is essential that there is a critical look and that the models can be examined by researchers (not just horologists or restorers), confronted with reality, commented upon, etc. No one should have the final say on a model. For example, the instigator of the models of Vaux-le-Vicomte, Cluses, etc., also directed the modeling of the horizontal clock described in Diderot and d'Alembert's *Encyclopédie* which he moreover inaccurately attributes to Julien Le Roy, but this model is open to criticism. In addition, unsupported criticisms were made by Simon-Fustier to the authors of the *Encyclopédie* and these criticisms cast a certain doubt on the neutrality of the encyclopedic enterprise which is advocated by the same person.

It should also be noted that models which are not open, that is to say for which users are not free to manipulate, measure, etc., the elements as they wish, and in the software of their choice, will inevitably have to be redone one day. This is the case for the models of Vaux-le-Vicomte, Cluses, Mafra, and others such as the one made in Strasbourg. Certain non-open models which are based on choices (any choice is questionable), such as for example the horizontal clock of the *Encyclopédie*, may even have to be started from scratch, perhaps with different choices.

Furthermore, if we simply consider the question of the library of mechanisms, it would be much more useful to produce on the one hand a library of simple mechanisms, particularly on gears, and on the other hand a typological analysis of tower clocks. It would also be useful to develop ways to automatically combine simple structures to make more complex mechanisms, and nothing like that exists to date. There is a lot of unexplored research potential in which a company could try to innovate. We can go even further, and consider the creation of a virtual technology museum, of which 3D models would only be elements. Such a museum is still far from existing and the Chronospedia project only offers snippets of it, as you can see by reading my article [4] on the subject.

Finally, we can wonder whether a library of mechanisms created by a clock restorer will really be adopted by other craftsmen who generally do not want to be dependent on one of them. Do craftsmen really need such an encyclopedia? And isn't there a risk that such an encyclopedia could be copied, as were all French

vital record archives by the Filae²⁰ company? If so, this may lead to further fragmentation.

2.8 3D and saving horology know-how

I don't think that 3D is essential to save horological know-how. It is not certain that there is really a danger and that there is such a great need to reconstitute know-how. Moreover, the demand, particularly at the level of tower clocks, is almost non-existent. The 3D technology can certainly help the public discovering or understanding certain mechanisms, but this discovery can very well be made with the clocks themselves. Even very sophisticated mechanisms like striking watches can today be studied without the help of a horologist and without 3D. Those who want to learn and are able to learn can learn. As far as tower clocks are concerned, they are generally so simple that 3D is not at all essential to their study. I'm not saying that 3D is useless here, but it is not a critical medium.

Let's just take for example a relatively ordinary tower clock such as that of Vaux-le-Vicomte. What is the associated know-how that should be saved? What one needs to know to do is to study how the clock works. In order to do so, one doesn't need 3D on site, one merely needs to have some knowledge of mechanics, to know what gears are, etc. Then one has to know how to disassemble the clock. In order to do so, one has to know what screws, nuts, plugs, etc. are. Again, there is no need for 3D here. And obviously, it takes a little intelligence to disassemble a clock. No clock restorer needs 3D to take care of such a clock. Then, we may of course want to simulate a clock, but this can be done in 2D, there is nothing that particularly requires 3D. If there are parts to be remade, there are usually other similar clocks from which we can draw inspiration. If there are broken teeth, one must either know how to rebuild an entire wheel, or how to repair only the broken parts. For this, if we want to recreate the gestures of the past, we would need videos explaining the techniques (for example dovetail insertion) more than 3D modeling. The same applies when bushings need to be changed, pivots need to be polished, new pivots need to be planted, etc. In fact, there are already videos for all of this, but they are scattered in different places. It may also be useful to gather information on surface corrosion, etc.²¹ And for more complicated tower clocks, 3D modeling will be even less useful in safeguarding know-how, since these tower clocks will be even rarer.

On the other hand, 3D has a clear utility outside the horological industry, not for saving horological know-how, but in order to provide access to mechanisms

²⁰<https://www.filae.com>

²¹Curiously, all this know-how which would be useful to bring together in documents, files, videos, etc., is the know-how that a certain number of restorers (including Simon-Fustier) do not want to communicate in their reports.

which are difficult to access if you don't have them in front of your eyes and in your hands. The use of 3D technologies could therefore help attract young people to the horological profession by modernizing it.

But what is happening instead is that some people today are trying to make people believe that 3D is essential and that horological knowledge will disappear without it. This opinion is completely unfounded, but it obviously has an economic objective.

In other words, the 3D advocated by certain clock restorers serves these watchmakers much more than the heritage itself or the recipients of this heritage (we do not intervene on the heritage for the heritage, but for those who benefit from the heritage). It is in fact nothing more than a business model. Moreover, if the clock restorers who are active in 3D were really concerned about heritage and its conservation, they would even work voluntarily on a survey, which is clearly not the case. (And of course, they would communicate with those working on this conservation.)

2.9 The priorities for horological heritage

The priority must be to save and document horological heritage and to make this heritage, its documentation and its archives, accessible to all, entirely and without discrimination. Note that in almost all cases, restorers, whatever their diplomas and titles, do not sufficiently document the objects going through their hands. On this topic, you may want to read the summary [5] that I produced based on a certain number of restoration reports.

In the case of clocks, the general documentation begins with a survey. I myself have inventoried (voluntarily) about a thousand tower clocks, but a single person cannot do this work for an entire country (especially on a voluntary basis!), and this work should be organized by the Heritage Administration like what was done for organs or bells in France.

It must also be understood that *a clock restorer is not de facto the person best suited to carry out such a survey*. Carrying out a survey is based on long experience, it cannot be improvised. However, clock and watch restorers usually know very little about tower clocks and their commercial activity practically prevents them from engaging in voluntary archiving and research activities. Even the French watchmaker Jean-Baptiste Viot, who has examined several tower clocks (without necessarily taking precise measurements), does not seem to have published any detailed description of a tower clock. Nor do his restoration reports describe the works in detail. *There is in fact almost a logical contradiction between craftsmanship on the one hand and the scientific work of survey and study on the other*. Knowing what to measure in a limited time, knowing how to explain, etc., cannot be done by someone who has never done it, or who has only had a few

tower clocks in his/her hands and has no sufficient background and experience. It may take ten years or more to acquire the skills necessary to make effective readings from a clock and be able to describe it. It is also a entirely different profession from that of the horologist. We obviously cannot expect everyone to have this know-how, but it can, to a certain extent, be shared. Furthermore, a survey can be conceived in two phases, first a preliminary survey phase (with a few photographs and a minimal description) and then a more in-depth stage carried out by researchers (not necessarily horologists) on the basis of the preliminary survey.

2.10 The dangers of 3D

3D is not without its dangers. *One of the dangers is that 3D is seen as a substitute for more traditional scientific documentation.* 3D then has a good chance of harming the documentation of a clock. In reality, 3D should supplement the scientific documentation (which must also be entirely public, without discrimination), it should not replace it. We can also see that the few creations accessible in 3D do not include all the details, not all the views, etc. Even the one I made for the Notre-Dame de Paris clock does not meet all expectations.

In fact, *3D often gives the illusion of easy understanding.* Some curators or other people might now believe that, thanks to 3D, we will finally be able to explain what was previously difficult to understand. The reality is that there are always things that are difficult to understand, and which cannot be understood visually in five minutes. There are things that require a mathematical approach, and it is not 3D that will create this understanding. 3D can then present itself as an illusion, a bit like when we believe that screens will revolutionize teaching in schools, or that GPS will allow people to better orient themselves. The reality is quite different, and those who use GPS (there is no pride in doing so!) often no longer even know how to find their way with a simple map.

Another danger is that 3D leads to losing sight of the priority of survey and documentation. We can also see that those who are most active in 3D technologies are not particularly active in surveys. Large amounts of money risk being spent on 3D developments, while the mechanisms (possibly in danger) are still neither studied nor safeguarded. It is not 3D that will save the thousands of mechanisms languishing in church towers and elsewhere, which should (and could) be quickly surveyed, and on the contrary, 3D can harm the conservation of mechanisms in danger by making people forget a much higher priority.

These dangers are all the more real as 3D is advocated by people on the basis of titles which do not sanction knowledge in the field of 3D, nor even technical knowledge, and that those who make choices, or propose funding, for example trade chambers, or even ministries, are experts neither in horology nor in 3D. The danger is then considerable. And I am afraid it is unfortunately real.

2.11 Summary

We must remember that the most important thing is to have a global approach, to not only look at what 3D brings in a certain context, but also to look at what it takes away elsewhere. The choices we make for heritage must be those that offer the most possibilities and the best possibilities for heritage. This means that conservation, surveys and documentation must take precedence over modeling, and that open and free modeling must take precedence over closed and discriminatory modeling.

3 The origins of the Chronospedia project

Now that I have given a relatively thorough overview of 3D in the context of horology, I will describe the origins of the Chronospedia project, as far as I understand them. But be aware that there may be some inaccuracies in the chronology, as some clock restorations may have started before they were advertised in the news.



Figure 2: The welcome page of <https://www.horlogerie-ancienne.fr>.

The root of the current Chronospedia project is the desire of expansion of Mr. Simon-Fustier, whose workshop is located near Lyon in France. In the 2010s, he set up his web site <https://www.horlogerie-ancienne.fr> (figure 2). This site does no longer seem to be developed, but shows the ambitions of Mr. Simon-Fustier around 2020. At that time, the small workshop (the ‘FSF group’, actually only three persons) claimed to be organized in three divisions, one for the traditional workshop, one for 3D modeling (then called *Chronosvision*) and one for a teaching division called “*Institut français d’horlogerie*” (“French Institute of Horology”). Let me immediately stress that this is no official “Institute” and that

it wasn't then (and still is not) affiliated with any University. In addition to these three parts, the site had a set of pages called *Chronospedia* which was actually a kind of embryonary horological encyclopædia. In fact, before 2020, this part only contained a lexicon with horology definitions. For instance, for “engrenage” (gear), the definition given was

Le but d'un engrenage est de transmettre la force d'un mobile, dit menant, à un autre, dit mené. Les dents et les ailes des pignons sont inscrites entre trois circonférences : la circonférence totale ou des sommets ou des pointes ; la circonférence de base ou de fond de dent ; la circonférence primitive c'est à dire celle où le flanc de la dent commence de s'arrondir pour former l'ogive de la dent. Un engrenage d'horlogerie est considéré comme parfait lorsque les circonférences primitives des deux mobiles menant et mené sont tangentes.

which is in fact quite simplistic and shows a very limited knowledge of gear theory.²²

For “*horloge astronomique*” (astronomical clock), the definition was even more terse:

Horloge indiquant un certain nombre d'informations concernant le soleil, la lune, l'équation du temps, les saisons, fêtes religieuses. . .

Some of the definitions were/are in fact wrong. For instance, for *barillet* (barrel), Simon-Fustier considered the case where a rope or chain was wound on it, when in fact, in French at least, this word is restricted to a case containing a spring.

The Chronospedia part of the site also leads to some 3D reconstructions and to pages devoted to the horizontal turret clock described in Diderot and d'Alembert's *Encyclopédie*.²³ In fact, this clock was the first large project undertaken by Simon-Fustier's apprentice Sébastien Lucchetti. Simon-Fustier and Lucchetti used the 2D drawings in the *Encyclopédie* and made a proposal for a 3D reconstruction. Simon-Fustier attributed this clock to the famed French clockmaker Julien Le Roy (1686-1759). This attribution is in fact wrong, but more on that later.

In 2017, after that first large experience (perhaps preceded by some smaller ones), Simon-Fustier and Lucchetti made a 3D model of the Borrel clock located in the Vaux-le-Vicomte castle. Ever since, and despite several messages drawing his attention to the attribution error, Simon-Fustier has been attributing the clock

²²Incidentally, another clock restorer some time ago claimed in one of his reports that when two gears mesh, only two teeth should be in contact at a given time, which is wrong. This restorer really meant that one tooth from one gear should be in touch with one from the other gear, and not two teeth with two teeth.

²³<https://www.horlogerie-ancienne.fr/projet>

to Jean Wagner, but it is in fact a Borrel clock, even though the construction is the same.

In 2018, Simon-Fustier restored the electromechanical clock from the town-hall in Cluses and a 3D model was made. Around 2019, 3D models were made for the two large carillon tower clocks at the Mafra palace in Portugal. It is not clear what part Simon-Fustier had in the restoration of these clocks. It is possible that he only was responsible for making the 3D models.

In 2019, Simon-Fustier also obtained the title of “*maître d’art*” (master of arts) which is a title given to a team made of a craftsman and an apprentice for the transmission of know-how. It is important to stress that this title is not some certification of horological knowledge, but rather a pledge to perpetuate knowledge, and therefore an incentive to keep a craft alive. Both the master and the pupil present a project and they are given three years to fulfil it. In Simon-Fustier’s case, his pupil was not Lucchetti, and the project was not directly about 3D modeling. Rather, the pupil was another of Simon-Fustier’s apprentices, Robin Putinier, and the three-year project was about making a physical reconstruction of the *Encyclopédie* clock. This is the description of the project in the official nomination to the title of “*maître d’art*”:

Le Maître d’art et l’Élève ont choisi un ambitieux projet comme fil conducteur de la transmission de savoir-faire : fabriquer l’horloge horizontale de Leroy, décrite dans l’Encyclopédie de Diderot et d’Alembert en utilisant, pour chacune de ses quatre parties, des techniques issues de différentes époques, du XVIII^e au XIX^e siècle. Cette réalisation commune est pensée comme un chef d’œuvre qui serait à la fois représentatif de 300 ans d’histoire des techniques horlogères, mais aussi comme le témoin d’une passation réussie.

As far as I can see, this project (which would have been quite interesting) has never been completed. I have in fact never even seen the start of it.

It should be stressed that Simon-Fustier is currently (2024) the only clock restorer in France to have the title of “*maître d’art*” and he is apparently also the only one to have a “*brevet de maîtrise supérieur*” in horology, which he obtained in 2009. This is the source of some confusion, because this “*brevet*” is also not about technical horology or 3D, but about mastering the management of a workshop. It is important to stress this difference, because we will see in the sequel that a lot of confusion has arisen from this situation. These two titles or diplomas should not be confused with, say, some University degree in horology, which they are in no case. In particular, the title of “*maître d’art*” is given as a result of an application, and it is not some national competition. It is possible that Simon-Fustier

was the only one to apply when he obtained that title.²⁴

Around 2019, Simon-Fustier has also been involved in the assessment of Besançon's astronomical clock, with a team headed by the French clock restorer Ryma Hatahet. This assessment has been clouded in mystery, and I am unsure whether the badly needed scientific documentation of the astronomical clock will ever become available, given that the patrimonial administration is very reluctant to communicate and is not working with scientists.²⁵

Around 2020, Konstantin Protassov, who is not a clockworker and has no background in horology conservation or 3D modeling, became associated with Simon-Fustier's project, and little by little the focus shifted to 3D modeling and the name Chronospedia, which was initially an extension of the *Encyclopédie* project, merged with "Chronosvision" which was altogether dropped.²⁶ Since 2020, Simon-Fustier and Protassov have developed numerous contacts, in particular with museums, in order to "sell" their project. Simon-Fustier has appeared on television, a new repository has been created thanks to a partnership with the French INIST institute, and the idea became to provide more and more "3D models" of clocks to the public.

In the meantime, in 2021, Simon-Fustier was sent to Cairo in order to examine a 19th-century tower clock, apparently by the French government at the request of the Egyptian government. Unfortunately, there has never been a report on this visit, and no one (except Simon-Fustier) knows exactly what were the problems of this clock, nor the origin of this clock. The clock was a gift from France, and it would have been useful to have researchers collaborate on that project, or at least be informed about the details of the clock. Myself, for instance, having examined a thousand tower clock, I might have had some ideas about the type of clock involved. Incidentally, Simon-Fustier was not chosen to repair the clock, but instead the Egyptian administration found a competent clock restorer locally.

And recently, Simon-Fustier and Protassov have sounded foreign audiences, such as the British Museum, the Antiquarian Horological Society, and the NAWCC where Protassov is presenting the Chronospedia project in June 2024.

²⁴Simon-Fustier, incidentally, has also registered in the "Who's who" directory, see <https://www.whoswho.fr>.

²⁵I had in fact been involved in the assessment of this astronomical clock, but for some untold reason, I was dropped from the project. Descriptions of that astronomical clock could have been published many years ago, but it is likely that that will never happen.

²⁶It should be noted that both "Chronospedia" and "Chronosvision" are incorrectly formed words. "Chronos" is not a prefix, and correct words would have been "Chronopedia" and "Chronovision."

4 Chronospedia's expansion strategy

Chronospedia's strategy seems to be to expand as much as possible and to reach to foreign countries, especially the UK and the US. I assume that other contacts are planned, perhaps in Germany, the Netherlands, Italy, Spain or Portugal. What we can witness is nothing else than a commercial strategy. In fact, it is hard to convince oneself that the priority of those behind Chronospedia is the horology know-how, but it seems rather to be to control the market as much as possible, in particular given that no one else seems to currently have the same ambitions. This strategy goes however at the expense of quality, in that expansions take place even though many tasks are left unfinished. For instance, even though very little has been made in France and even though the authors of Chronospedia haven't published a sole technical description of a clock, Chronospedia is working hard towards convincing the UK and US to join this project. One consequence is that the project promises many things, but has in fact fulfilled very few of these promises. This is very strange, and one wonders how this is possible. How is it possible to progress, to move on from one projet to another, without ever completely finishing or developing the projects that have been started? This is like climbing on a ladder floating in the air. This is also reminiscent of Google's strategy for the digitization of books in the early 2000s, where the quality of digitization of a number of technical books (especially with fold-outs) was insufficient, and where Google's strategy was clearly to control the market, and only later to fix the problems. Now, Google has improved the way it digitizes fold-outs, for instance, and it can focus on better digitization rather than volume, because it has a total grip on the market. Chronospedia's strategy may be exactly the same.

One may wonder what is the use of such an expansion. Is such an expansion really necessary? For instance, Chronospedia has recently made a 3D model of the very common US movement Seth Thomas 89 from the 1920s. This is a very simple movement, very little known in France, but very well known among American clock restorers. One can speculate that this movement was modeled in 3D especially for that reason, that is because it will resonate among US horologists. It is a strategy. However, this does not answer the question about the usefulness of that expansion. Is Chronospedia's aim really to save the know-how of horology, or is there another aim? Perhaps this is all about becoming famous? Isn't it strange that a physicist with no contributions to horology is associated to a project which is about horology's know-how? Wouldn't there be a personal gain in this project? And isn't there a long-term hope that this project will be financially fruitful? These are all questions that must be asked and that are underlying a project that claims to be only for the good of horology.

But even though Chronospedia hasn't done much for the conservation of

horology's know-how²⁷, it is still trying to expand beyond showing animations of 3D models. First, whereas Chronospedia was initially focused on models created by Simon-Fustier's team with SolidWorks, it is opening towards other software such as Inventor, Rhino, etc., and it has invited contributions by the users of these software. Second, Chronospedia also tries to expand its activities towards Virtual Reality (VR), and Augmented Reality (AR)²⁸.

Finally, Chronospedia's team is also trying to automate the construction of 3D models and this is the aim of Vincent Commin's PhD which started in September 2023. It is interesting to see that this subproject is not mentioned on Chronospedia's site, at least not at the time of this writing (June 2024). We will see whether that will succeed or not, but the underlying ideas are certainly not new. Parameterizing constructions has been used in architecture and other domains for many years, and I have myself used such methods with clocks, although not by using clouds of points. In any case, automating the production of 3D models will require a shift in methodology for Chronospedia's team, and it is not at all sure that this will work.

5 The narrative about the conservation of horology's know-how

Whereas in the 2010s Simon-Fustier's focus was on the innovation of 3D models for clocks, this focus has shifted in the early 2020s towards the claim that these models will be part of a large undertaking to save horology's know-how from oblivion. In 2022, the Chronospedia team wrote the following [9]:

Chronospedia sera une base de donnée open source de mécanismes modélisés en 3D pour faciliter la transmission et pallier l'absence de littérature technique. (...)

Si rien n'est fait le savoir-faire [en pendulerie, horlogerie et horlogerie d'édifice] sera perdu lorsque les derniers maîtres artisans formés à l'ancienne partiront à la retraite et en 2050 on tombera dans l'archéologie horlogère. (...)

²⁷Incidentally, when the Chronospedia site was set up, it showed glimpses of archives, horological class notes, etc., but these documents have since vanished. In fact, the documents were never shown entirely, and their utility could hardly have been evaluated. It is possible that some of Chronospedia's projects have been transferred to the *Watch library* project (watchlibrary.org), a separate project to make a number of archives and horological documents available, although this project is, like Chronospedia, less open than it would appear at first glance.

²⁸In that context, I recall that in 2021 I have authored what is probably the first mobile interactive application for a tower clock [7]. In 2022, I have directed experiments in AR with a Microsoft HoloLens headset [4]. Incidentally, I have been teaching mobile programming for many years.

D'autre part, la formation reçue nous permettait d'envisager sans crainte le replantage d'un pivot cassé ou trop usé, le bouchonnage des platines et paliers, le remplacement de dent. .(. . .) Les jeunes qui vont arriver dans le métier n'auront pas cette chance et le patrimoine mourra. (. . .)

Ils n'auront en tête aucune "bibliothèque de pannes", aucune méthodologie de diagnostic et, encore plus grave, aucune source documentaire explicite. (. . .)

La rareté des sources et le manque de détail rendent très compliquées les restaurations correctes de mécanismes anciens, fabriqués en pièce unique ou en toute petite série.

In 2023, Boudart and Protassov [1] wrote the following

L'évolution de l'industrie horlogère mécanique française et mondiale a induit le fait qu'aujourd'hui la quasi-totalité de cette activité est destinée à la production de montres. Ainsi dans les écoles d'horlogerie, toute la partie concernant les pendules et horloges et encore plus l'horlogerie d'édifice n'est presque plus enseignée. Si rien n'est fait, le savoir-faire horloger en pendulerie et en horlogerie d'édifice aura disparu d'ici à quelques années, lorsque les derniers horlogers formés « à l'ancienne » partiront à la retraite. Il est donc urgent de mettre au point un système qui permet de conserver le savoir et le savoir-faire horloger. La solution peut venir des techniques 3D et de réalité virtuelle, largement utilisée dans l'industrie. L'idée d'utilisation des méthodes 3D dans la restauration des horloges anciennes a été introduite par François Simon-Fustier, l'Horloger de la Croix-Rousse, Maître d'Art en Horlogerie. En parallèle de sa pratique quotidienne de restauration de mécanismes du XVII et du XVIIIème il a développé une expérience significative de l'utilisation de la 3D dans l'horlogerie ancienne au cours des nombreuses collaborations en France comme à l'étranger pour la sauvegarde du patrimoine horloger : Château de Vaux-le-Vicomte, Musée d'Horlogerie et de décolletage de Cluses, Musée du Temps de Besançon, Palais National de Mafra au Portugal, . . . Le travail déjà accompli démontre que si l'on crée une bibliothèque de modèles 3D de mécanisme, il devient dès lors tout à fait possible de réaliser des animations, des déconstructions, des vues partielles, voire des manipulations virtuelles.

These narratives looks like a Doomsday warning and basically say: "Chronos-
pedia will save you, otherwise the entire clockmaking knowledge will vanish.
Please, join us!"

In fact, the narratives contain a lot of errors and false statements, and I feel it as a duty to correct them. First, in 2022 [9], the Chronospedia project is advocated to be “open source”, but the bare truth is that no 3D model is made available on Chronospedia’s site. STEP files are kept somewhere, but only for perennial storage²⁹, not in order to be made available to all. All the user has are animations, sometimes interactive. Somewhere the site says “if you need the models, we can provide them after having studied your demand.” In other words, the models will be available to some and not to others, depending on whether the Chronospedia team judges your project. This is not only not open, it also goes against freedom of research.

Both in 2022 [9] and 2023 [1], the Chronospedia team claimed that knowledge will be lost and that the new horologists will no longer know to plant new pivots or to replace teeth. This is true, but Chronospedia does not provide anything to save that knowledge. What about Simon-Fustier making videos of the know-how he wants to be saved and uploading these videos on his site? What about Simon-Fustier publishing technical descriptions of tools, of methods, and other things in horological journals? In the past ten years, no such initiative has been taken. Simply put, the 3D animations put online do not answer the main concern claimed by Simon-Fustier.

One of the claims of Chronospedia’s team is that there is a lack of documentation, or that the only documentations available are too old to be of value. This is simply not true. First, there are many books and descriptions of clocks. Some of them may be old, others more recent, but it is not because a clock description is from the 18th century that it has lost its utility. It is true some books may be difficult to access, but almost none is inaccessible.

There also appears to be no absolute need of 3D for the study of clocks, and most clocks can be described in 2D. In fact, as I explained earlier, 3D can obscure the explanations, rather than clarify them. In addition, the Chronospedia team claims that the absence of plans makes restorations difficult. This, too, is not true. More than 99% of restored tower clocks are handled without plans. There is just no need for complete 2D plans, let alone 3D models. The only things which are needed here and there are small drawings that can help understand some parts of a clock, or can help reassemble a clock.

The entire rhetoric of Chronospedia’s team is based on trying to justify the use of 3D in places where it is not necessary. The real utility of 3D is that its use makes the mechanisms attractive, the 3D models can be beautiful, they make it possible to interact with the mechanisms, and all these things fit nicely in museums and

²⁹Chronospedia plans to store the models in the 3D heritage archive at <https://3d.humanities.science>. However, at the time of writing (July 2024), Chronospedia does not seem to have deposited any. Moreover, this archive is primarily meant for 3D data obtained from 3D scans, and is not particularly tailored for CAD models.

other places. But for a clock restorer, this has little use.

In the 2023 article [1], the Chronospedia team also claims that Simon-Fustier was the first to have the idea of applying 3D to the restoration of ancient clocks. This is wrong. 3D has been used for that purpose already in the 1990s, and perhaps before, as I wrote above. The Chronospedia team also writes that the work done “demonstrates that if one creates a library of 3D mechanical models, it becomes possible to produce animations, deconstructions, etc.” But I made 3D animations of clocks more than 20 years ago, and others have probably done so before me! The work of Simon-Fustier may demonstrate some things to him, but the utility of 3D in horology was known to others already 20 years ago!

Furthermore, the 3D library is presented as a catalog of parts from which one can draw [9, p. 120] to create a more complex assembly. This is a somewhat simplistic vision, because in order to be assembled, parts cannot be created independently. The parts must in fact already be linked before being assembled. For example, if we want to insert a sphere into a cube, we cannot separately create a cube and a sphere; these two pieces must be designed with their assembly in mind. This obligation means that in order to properly design a mechanism, we must take into account the constraints between the parts before designing them, and not simply afterwards. I am afraid that the models made by Simon-Fustier’s workshop have not sufficiently taken this aspect into account and that they rely more on individual models assembled (from measurements) than on an overall design, which almost always introduces errors. This is also what Simon-Fustier suggests in the restoration report of the Cluses town hall clock [8], namely that the dimensions must be adjusted. This is clearly not the right way to proceed. If such an approach were adopted in the construction of planes or boats, the greatest disasters would be expected! We can also notice gross errors in certain models of this workshop, in particular for the clock of the North tower of the Mafra palace. Parts of the gears have been excessively simplified (e.g. gear spokes), and there is at least one case of collision, which is an evidence of inadequate methodology in reverse engineering the mechanism.

The experiences put forward by Simon-Fustier in cultural mediation [9, p. 121] also do not entirely correspond to reality. In Vaux-le-Vicomte, contrary to what the author claims, no animated video is presented to the public, at least as of June 2022, even if this seems to have been initially planned. And these videos are not entirely on the internet either.

Another important observation is that the Chronospedia authors do not mention what has been made before them, and obviously they are not interested by it, and perhaps do not even know it. What seems to interest them first hand, is to let others believe that they have been the first ones to use such and such technique. But the truth is that they were not the first ones to use 3D for tower clocks or oder pendulum clocks. They were also not the first ones to think about creating para-

metric 3D objects. This has been applied to clocks, but above all in other domains such as architecture. The Chronospedia authors were also not the first ones to put a 3D clock on a mobile device, nor to use virtual reality, nor augmented reality. And they were not the first ones to provide models in open source (or to claim doing so, as a matter of fact).

Readers of the Chronospedia site and articles should therefore be very cautious. Claims should be fact-checked, and most of the “firsts” are not firsts. The dates should also be verified. In his 2022 article [9], Simon-Fustier claims to have started to use 3D in 2008. I don’t know if this is true, but the earliest experiment that was made publicly available is that of the *Encyclopédie* clock around 2015. And according to Simon-Fustier’s site³⁰, Sébastien Lucchetti has only been working on 3D since 2015. I therefore have some doubts on the date of the first claimed experiments in 3D.

The above examples raise a number of questions about the narrative and the real intentions of the project which is perhaps not really about saving the know-how of horology, at least not to begin with.

Another problem that was already mentioned is that Simon-Fustier, without any university degree, without any published research work, has the audacity to title a part of his activities the “French Horological Institute.” This doesn’t fit with the aims of an encyclopædia. Encyclopædias have traditionally been written by scholars, and one does not become a scholar without publishing research articles and without accepting the judgements from the scientific community (and not only clock restorers).

6 The current state of Chronospedia

Now that I have given an overview of 3D in the context of horology, and that the origins, expansion strategy and narrative of Chronospedia have been analyzed, it is time to pause and see what is the current state of the Chronospedia project. What does it contain? Is it useful? Who can benefit from it? How can it be improved?

The current Chronospedia site basically only contains a few images of clocks and some 3D animations. Some of the animations explain more or less how the striking of clocks work. A few clocks can be viewed with a 3D viewer, but the clocks can only be manipulated in their entirety and it isn’t possible to get too close to the clocks. The clocks of Vaux-le-Vicomte, Mafra or Cluses can not (yet) be viewed on the site (as of June 2024). This is somewhat surprising, as the models of these clocks do exist and that those of Mafra and Cluses have separate 3D viewers.

³⁰<https://horlogerie-ancienne.fr/equipe>

The Chronospedia site basically contains no 2D drawings and one is led to believe that only 3D can provide adequate explanations. The lack of 2D drawings is a real hindrance, because 2D drawings are very useful in explaining specific points in a mechanism, without being cluttered by irrelevant parts. The site also contains basically no downloadable documents, no PDF descriptions, etc. An encyclopædia should not only be virtual, but should also, to some extent, be printable, and this is currently not the case. Of course, some of these limitations may be removed in the future.

In the following sections, I will have a closer look at some of the problems of Chronospedia, in particular concerning the accessibility of the 3D models, the quality of interaction, the conservation of know-how and the access to restoration reports, and in general the negative side effects of 3D for horology conservation.

6.1 The accessibility of the 3D models

As already mentioned above, the Chronospedia site does not provide *any* 3D model. People unfamiliar with 3D may be content with 3D animations, but the truth is that 3D models are withheld from the viewer. They are obviously intentionally not provided. Although Chronospedia claims to be “open-source”, this is in fact not the case. Very little can be done with the animations provided, except a very tedious process of reverse engineering. In most cases the animations do not give access to all the parts of a clock, and some parts will remain in the dark.

Openness means something else. The 3D models should be made available, at least in an open exchange format such as the STEP format. This format should not be restricted to the purposes of perennial storage, but should be accessible to all. Moreover, the models should be split in their various parts, otherwise it will be very difficult (but possible) to use them efficiently. If a model is provided in the STEP format and for each of its parts, it can then be manipulated by others, and other users can for instance create new animations, new explanatory documents, etc. This is what I have done for the Notre-Dame clock in Paris.³¹ Splitting a model in all its parts (in my case, I provide 359 parts, and this is in fact far from all the parts that make up the clock) takes some work, but it is necessary for the purposes of openness.

It should be noted that the Chronospedia site claims that a model can be made available if the request is deemed legitimate. This, however, only leads to discrimination, as some people (such as me) will be denied access, whereas others will be able to use the models. Moreover, the current restricted access will certainly not answer the need to have access to the separate parts.

³¹See <https://github.com/roegeld/notredame>

In summary, the access to the models (in STEP format) should be entirely free, anonymous and non discriminating.

6.2 The quality of interaction

As mentioned above, the Chronospedia contains two types of media. There are 3D animations, mostly created with SolidWorks, and there are a few 3D models only available through a 3D viewer. Some of the animations are or will be created using the *Blender* software.³²

Chronospedia's team, in particular Titouan Boudart who work on the 3D viewer, seems to have chosen existing 3D viewers, such as Google's ModelViewer and Voyager Explorer. However, in my opinion, this is far from adequate. An application for clocks should have a specially tailored 3D viewer. For instance, when I created my Android application for the Paris Notre-Dame clock (figure 3), I did not use an existing viewer, but created a new viewer. This enabled me to obtain a (relatively) good interaction with the model. I was able to move around the model, to get closer or farther, to select parts, to obtain information on the parts, and even to animate the models and control that animation. I could have added more features, such as the possibility to hide parts, or to display more information, but I did not want to do more. In any case, none of the features found in my application are currently provided by the Chronospedia team. In fact, the interactions featured by Chronospedia are currently very poor.

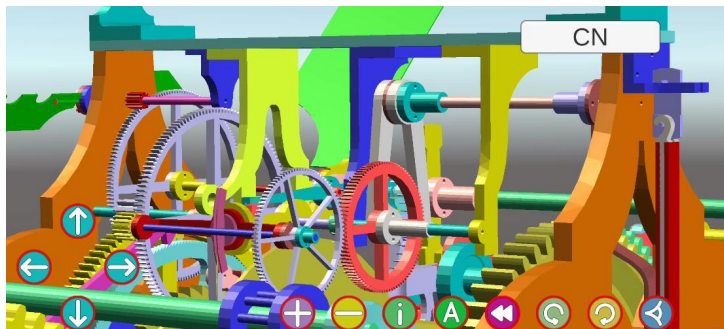


Figure 3: A screenshot of the Notre-Dame clock Android application.

Incidentally, the models shown by Chronospedia have colors that try to mimic the real colors, for instance grey for steel, brown for bronze or brass, etc., but

³²Incidentally, it is funny to see that Chronospedia's team is now using tools that I have been using for a long time. The animations I made in 2021 of the Notre-Dame clock on *youtube* (<https://www.youtube.com/@horlogenotredame>) were mostly made with *Blender*.

in the end the result is a rendering with only very few colors, and this is hindering the readability of the model. An actual clock is often more readable, because the parts do not all have the same color, some have stains or marks, etc. In my own model, I have chosen instead to use much more vivid colors. This may be shocking for some,³³ but I think it is more useful, at least for explanatory purposes, than having all the parts of the same color.

It is interesting to observe that the main page of the Chronospedia site currently displays a film created by Marc Voisot and his colleagues on the 1578 Habrecht clock from Toulouse. It is somewhat surprising to see that the animation put forward is not one made by the Chronospedia team itself! Now, the Habrecht clock movie is a very nice film, but at the same time it is also very incomplete. It does not provide a real technical description of the clock, many details are not shown, and for instance the alarm clock which is part of the clock is not described at all. Such a movie can in no way be considered sufficient for purposes of research. What is needed in this case is a free access to the archives related to the clock, to the complete restoration report and to photographs of details of the clock. Such accesses must in no case be subjected to the will of restorers.³⁴

These examples should convince us that 3D or even 2D models are not enough, that interaction can and should be improved (for instance inspired by my experiments), and that text documents should also be provided and cannot be replaced by 3D models or animations alone.

6.3 The access to restoration reports

One of the most important thing for the conservation of know-how, and also for researchers and other persons who are unable to have a direct access to clocks or to their internal workings is to have access to restoration reports. Whenever a restorer works for a museum or for some other administration, he is usually bound to provide a restoration report. In fact, there are often two reports: a first preliminary report assessing the clock, and a second report describing the work done. These reports are usually very difficult to obtain, because restorers do not want to make them public. They view them as internal documents and they are often afraid to let others know what they contain. Some restorers claim that these reports contain trade secrets, but this is very seldom the case. In any case, in

³³Mr. Simon-Fustier once wrote that my 3D model of Notre-Dame is as “colorful as me”, whatever that means, but it was clearly an insult.

³⁴Unfortunately, Marc Voisot is also the restorer behind the *Passemant* clock at the Louvre and an astronomical clock in Nancy. In the latter case, Voisot has made it clear that his restoration report will not be available. The teeth counts and gear layout were therefore not given, although most of them can be guessed from photographs [2]. It is in any case interesting to see on Chronospedia’s site a contribution from someone who is a staunch advocate of secrecy.

France, there are legal provisions for accessing these reports, but both the restorers and the administrations still refrain to provide them. These reports are however essential for researchers.

When I wanted to describe the very interesting electromechanical clock at the Cluses townhall [3], I wanted to have access to the restoration report and to the photographs taken by the restorer. Eventually I obtained them, but asking them caused the restorer (Simon-Fustier) to complain about my demands, and even to write to my employer, who had nothing to do with it.

To this day, I still wish to access the restoration reports for the great Passemant clocks in Versailles and at the Louvre museum, and none have been provided to me. At the Louvre, I was only shown a 20 pages document, containing no photographs, and the Louvre claimed that it is the only report available, for the most important clock in the museum! This is certainly a lie. In fact, the Louvre has recently been condemned to provide me additional documents than those I already have, but the museum may still evade this order.

There are many other such examples, but one would expect that Chronospedia would contribute to the access of these reports. Mr. Simon-Fustier himself could for instance give access to his reports on the clocks in Vaux-le-Vicomte, in Cluses, in Mafra and in a few other places, but this has not yet been the case. In fact, this seems a bit of a contradiction with the aims of the Chronospedia project. One would also like to see the restoration reports of Marc Voisot, who has restored the Passemant clock at the Louvre, or of Ryma Hatahet, who is overseeing the restoration of the Passemant clock at Versailles, or the astronomical clock at Besançon. Currently, the scientific community is denied access to these documents.

The instigator of Chronospedia seems in fact much more interested in making the works of others accessible under his name, than of giving access to his own works, even when they concern heritage (and are therefore intended for the community). Let me give a few examples supporting this claim:

- When I first came in touch with Simon-Fustier in 2017, I asked him what was wrong on the Vaux-le-Vicomte clock that he was going to restore, I had read that there was a problem with some pivot, and he refused to answer. Instead, he asked me what were my diplomas and he said that he was the only one in France to have the *brevet de maîtrise supérieur* in horology (which is not about technical knowledge, let me remind it). In other words, he would only answer to peers. Is this absence of communication compatible with the will to save the horological know-how?
- In the case of an astronomical clock from the La Martinière high school in Lyon and restored by Simon-Fustier in 2009-2010, the Claude Martin Foundation which owns the clock did not have the report (was there even one?)

and Simon-Fustier claimed to no longer have the report as a consequence of a loss of computer archives, which is doubtful.

- In the case of the Cluses town hall clock restored in 2018, Simon-Fustier initially refused to communicate the 500 photographs that he left in the municipal archives. What were they for then? I only obtained these pictures from the city hall in May 2023, after the Fontainebleau castle was ordered by the Court to communicate similar files to me.
- In the case of a barograph restored in 2021 for the University of Clermont Auvergne, Simon-Fustier obscured a large part of his restoration report, therefore blocking the dissemination of knowledge and also thus refusing to submit to the analysis of researchers. On the other hand, as far as I can see, the restoration report only has a shallow description of the barograph.

6.4 The negative side effects

Creating a catalogue of 3D models may sound very interesting and useful, and in fact it is. We can easily imagine that we will one day have an encyclopædia with hundreds or thousands of 3D models, that we can pick up easily and study conveniently. We could for instance decide to print some of these models, or use some of these models or parts to build other models, and so on. Such a catalogue could be an invaluable help for the conservation of the horological heritage. But for the same reason as an encyclopædia of insects will not alone save the world of insects, it needs to be supplemented by field work. If we consider for instance that the author of an encyclopædia has the entire knowledge of a domain, and that the objects need no longer be looked at, we are going down a very dangerous pathway.

It is in fact necessary to have a broader view, not to see only what 3D can add to horology, but also what it can take away from it. This may be hard to perceive for those who are only working in 3D or those who are not working in the survey of clocks, or are no experts in the horological technology.

The problem here is not merely related to 3D, it really has to do with one field occulting another one. For instance, in school, too much screen time can be detrimental to learning. Using a GPS device causes us to lose our ability to read maps, and so on. It is easy to find such examples. In any complex domain, there are in fact competing means, and sometimes different means to reach a same objective. Work may for instance be done faster with better highways, but also if people are allowed to work from home. Which is best?

In the case of clocks, there are a number of useful things to do. One is (perhaps) to save the vanishing know-how in mechanical clocks, although sometimes

one may have to accept that some crafts vanish. Most of us have long lost the know-how to make fire with stones, and many other crafts have disappeared. Of course, in the case of clocks, there are still many mechanical clocks around and it is nice to see them working. It is also interesting to understand them. So, there may be good reasons to keep such a craft alive. However, for that to work out, a catalogue of 3D models is far from enough. As I mentioned earlier, if Chronospedia really wants to save that know-how, it should set among its priorities to provide (or gather) material on the work of a clock restorer, on its tools, etc.

But another very important priority is that of saving the clocks which are in danger, and also to facilitate their study. The clocks which are most in danger are the forgotten clocks in public buildings, in particular in churches. Many of these clocks have vanished, some have been vandalized, and they represent a very rich and varied heritage. Those who are not familiar with these clocks may think that they are all more or less the same, but this is not true. The Chronospedia site shows only one such clock, the one in Vaux-le-Vicomte, but there are many others. The priority with these clocks is not to model them in 3D, but to survey them and to let researchers access them and study them. I have personally examined about a thousand of such clocks, and there are hardly two identical ones. But my work only represents a tiny fraction of what should be done, and to which Chronospedia could contribute. A somewhat less important priority is that of surveying and studying the clocks in museums. These clocks are relatively safe, they are protected, but they have in most cases not been studied appropriately.

For these two cases, namely the tower clocks and the clocks in museums, there should be either global initiatives from the heritage administration (in France, the DRAC), or there should be initiatives from museum curators. But these administrations should keep in mind that research on clocks is not, in most cases, done by restorers, and if only restorers access clocks, the survey will be rather poor and many scientific developments will not take place. Most of the clocks I have examined have not been studied by restorers, and I was for instance apparently the first one to study in detail the Notre-Dame cathedral clock in Paris. Why haven't horologists done that work before me?

The danger of Chronospedia, and in particular of 3D, is that the focus on 3D is likely to take the focus away from tower clocks, and these clocks will then continue to vanish. Moreover, some measures of protection are counterproductive. For instance, some administrations are very protective with this heritage, they make it very difficult to access it, and eventually researchers like me find it more and more difficult to study these clocks. Restorers seem to have an easier access, but they do not produce research work. The same seems to apply to museums and for instance at the *Musée International d'Horlogerie* in La Chaux-de-Fonds, I really feel that researchers like me are not understood. Museum curators there and elsewhere don't seem to understand that there are researchers working on the

technology of clocks, and that non-horologists (such as me) are not necessarily merely historians.

These are some of the dangers that the conservation of horology is facing as a consequence of a too important focus on 3D technologies.

6.5 The overseeing committee

The current committee overseeing the Chronospedia project is in fact very questionable. Among its twelve members (Jean Davoigneau, Agnès Dumas, Claire François, Régis Huguenin-Dumittan, Pierre Judet, Florent Laroche, Frédéric Noël, Konstantin Protassov, Laurence Reibel, Frédéric Saby, François Simon-Fustier and Jean-Pierre Viennet), there is only one clock restorer and none of the members has ever published a technical description of a clock (in particular not the museum curators). No member of the committee has been involved in a survey such as of tower clocks, not even Mr. Davoigneau who has been working on heritage surveys. Those members involved in 3D (F. Laroche and especially F. Noël) have no experience in horology publications, or even in an horological survey. And no established historian of science/technology is involved. Finally, there is no member who can claim to be at the same time knowledgeable and experienced in 3D, in the survey of clocks and in scientific publications. For me, this is a serious problem, and creating such a committee is like gathering the ingredients of a recipe without having the recipe. You cannot cook that way!

Perhaps the root of the problem is that the Chronospedia project is not backed up by scientific research. I would have liked to see in the committee a number of international scientists, who have experiences in technical publications, the history of clocks, and also 3D technology. Where are they? Even the instigator of the Chronospedia project has no scientific publications on his behalf, and claims falsely that the *Encyclopédie* clock is from Le Roy and the Vaux-le-Vicomte clock from Wagner. That same person, without having worked on a clock survey, seems to decide alone that twenty different mechanisms are sufficient to cover the entire spectrum of clocks over five hundred years! The truth is that there is a much greater variety in clocks, but perhaps there are strategic reasons to claim that the domain can be covered with only twenty different types of clocks?

Another great problem is the pyramidal structure of the committee. All technical decisions are taken by one person alone. This is not good and it isn't right. Not only is this going to create a bottleneck, it also has a negative side effect for research, because that same person will try to control research. Eventually, research will be confined to restorers. But restorers do seldom publish, they have no research schooling and no research experience. They will nevertheless dictate their idea of research to museums and other institutions. This is in fact already the case, and I am often running into cases where restoration reports are very incom-

plete (for instance for an astronomical clock at the Fontainebleau castle [6]), or where some useful technical investigations have not been made (for instance at the *Musée International d'Horlogerie* for the Ducommun orrery). This will probably only become worse, once (non horologist) researchers are controlled by restorers.

One thing that the Chronospedia committee should therefore guarantee is the freedom of research. There must be a guarantee that researchers can work on technical objects, can have access to them, without restorers being able to decide that such and such research is not useful or not interesting. The last word on horological research must not be that of a restorer.

But the current attitude of a number of members of the committee is also a problem. A number of years ago, when I drew the attention of several persons involved in the restoration of the Cluses clock to the inadequacy of its documentation, to the fact that some “firsts” were not “firsts”, and to a number of attribution errors, and when I insisted to obtain the restoration report of that clock (which the mayor of Cluses initially refused to provide), Mr. Simon-Fustier sued me for libel. In fact, in a message he sent to several other restorers, he wrote that I would be the “martyr of Lorraine”!³⁵ This shows a clear will by Mr. Simon-Fustier to get rid of me, and by all means. In 2022, another member of the committee (neither experienced in horology, nor in serious 3D development) to whom I wrote of my worries about the Chronospedia project tried to intimidate me and threatened to write to my employer, even though my work here is done as an independent researcher. This seems to have been part of the broader effort to silence me and does not seem to be a very adequate answer to a researcher whose aim is to do the best for heritage conservation.

7 The future of Chronospedia

As I wrote above, I don't consider 3D models for clocks to be a priority and I do not believe that such an approach is the right one to save the horological know-how. In my opinion, the sole benefit of 3D models for the conservation of clocks is that they help the general public, not the clock restorers, to get a better knowledge and appreciation of these mechanisms. This may, or may not, help to save some mechanisms in church towers, but even if it does, it will not dispense working on general surveys and letting researchers (and not only restorers) access and study these works, in particular prior to any restoration.

Now, if the Chronospedia team wants to use the principle of Wikipedia for horology, it must above all be open. As far as the 3D models are concerned, anyone should be able to submit a model, in an open format such as STEP, and anyone

³⁵Lorraine is the area where I am working in France.

should be able to retrieve the created models (and not just animations), in a free way. If this is not the case, we will have a bottleneck and undemocratic and discriminatory functioning. Without a greater opening, data (3D models, measures, etc.) will be kept by a single person or a small group of persons, who will not have the time or desire to communicate them to another person wishing to access them. A closed system leads to a monopoly that it is essential to block from the start, because it harms the development of knowledge and the conservation of heritage. Such a system eventually has research and curation being controlled by a few persons, when in fact curators, researchers, and restorers have independent skills and each should be independent from the others, like in the separation of powers in modern countries.

But Chronospedia should not only be about 3D models. It should also help saving the know-how, describe tools, and provide tutorials for common techniques. One way to do so would be to take a comprehensive book on the subject, and to illustrate it with videos and other documents. This is much more important than creating 3D models.

It is also important that Chronospedia provides written documents, explanations, descriptions that can be printed. For instance, every clock which has been modeled should have an associated technical description. This is currently nowhere to be found. Simon-Fustier and his employees have made models of the *Encyclopédie* clock, of the clocks of Vaux-le-Vicomte, of the Mafra palace and several others, and no real documentation has ever been provided, as if 3D animations would be enough. But transmission of knowledge is not only about looking at beautiful things, it is also about providing data. For each clock, measurements should be given (this can be mere text files, there is no need for elaborate plans generated by SolidWorks), teeth counts should be given, simplified drawings of the gear layouts, etc. There should also be an associated history of the models: who made the models, when, with what software, etc. This is important for traceability, and in general it is important for the researchers, because these informations are part of the sources.

But even if Chronospedia is developing its coverage of know-how (which is currently basically zero), it should also make sure that providing 3D models and know-how information does not cause other priorities to be forgotten or to be diminished. For the purpose of the conservation of horological heritage, it is far more important to survey clocks in churches and other public buildings than to provide 3D models. Chronospedia could act as a lever towards the heritage administrations and induce them into organizing general surveys, which could then be made available to researchers.

And Chronospedia should also collaborate more with researchers in horology, with those who publish articles, those who study, and those who work on surveys. These researchers are not always horologists or restorers, yet they do have needs.

It is up to Chronospedia to take these needs into account and not to take decisions for them without consulting them.

But as I said earlier, as long as the Chronospedia project is not really open, none of this will work and I therefore strongly advise curators, researchers, and even clock restorers and others to turn away from it.

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