Dynamic Drawings in Enhanced Publications
note to the reader

This report describes the outcomes of a so-called Public-Private-Project (PPP) of the Royal Netherlands Academies of Arts and Sciences (KNAW) that makes part of a joint venture of the University of Amsterdam (UvA), Vrije University Amsterdam (VU) and the KNAW to support research in the digital humanities that focuses on collaboration between research institutions, non-profit organizations (e.g. cultural heritage institutions) and private companies in the creative industry to develop innovative digital research methods and new modes of valorization of humanities knowledge.

The KNAW-Public Private Project: Dynamic Drawings in Enhanced Publications was a collaboration between a historian of science of Museum Boerhaave Leiden seconded for this research to the Huygens Institute for the History of the Netherlands (Huygens ING), a game development company Wild Card (Dylan Nagel), scientific programmers of Data Archiving and Network Services (DANS) and the publisher Brill.

Purpose of the collaboration was to create new publication formats that enhance critical understanding of historical sources and to develop new archiving methods and business models to support the reuse of these formats. Historian of science Tiemen Cocquyt (HI/Museum Boerhaave) and Dylan Nagel experimented one day per week for a period of nine months with the development, preservation and reuse of animations of static illustrations of scientific laws, processes and the working of mechanical instruments and tools. These animations were developed to enhance the understanding of complex, often abstract descriptions in seventeenth century publications of the sciences.

In total six animations were produced that can be activated by clicking on QR codes next to illustrations in books on/facsimiles of seventeenth century works on astronomy, physics, biology, fortification, land surveying and mechanical engineering. The aim was not just to produce creative illustrations, but interactive scholarly multimedia animations that would contribute to a critical interpretation of the seventeenth texts and comments hereof. The experiment did not limit itself to creation of animated visualizations. Maarten Hoogerwerf (co-applicant) and Heleen van de Schraaf DANS created strategies and designed workflows for the re-use of the enriched publications to be represented on the website of Brill Publishers.

Michiel Thijssen (Brill) joined the project committee, to bring in the publisher’s perspective for the development of business models that together with the new archiving methods must support the sustainability and re-use of the enhanced publications. Other members of the project committee that met monthly were Leen Breure (DANS/UU) an expert of enriched publications, who provided much feedback on methodological and editorial issues, Huib Zuidervaart (HI) who critically assessed the cases with physics content and Charles van den Heuvel who provided information for the fortification and land-surveying cases.

The end report consists of three parts. The first part written by Tiemen Cocquyt describes the choice of cases, the development of story boards and the architecture of the publications enhanced with animated visualizations as a result of his close collaboration with Dylan Nagel (Wild Card).

The second part written by Valentijn Gilissen and Maarten Hoogerwerf describes requirements for the development of archiving and representation workflows of enriched publications for re-use.
In the third and final part, Michiel Thijssen sketches some potential future business models for these experimental enriched publication formats. It is followed by a general conclusion of the project.

The dynamic visualizations can be accessed using the persistent identifiers in the captions of the screenshots in this document, or via the project webpage: http://demo-brill.dans.knaw.nl. The persistent identifiers will redirect you to the visualizations on the project webpage. Once the project webpage is no longer available, the persistent identifiers will automatically redirect to the archived copies of the visualizations. The archived copies can also be found via the project webpage. If you are reading this document in paper format and you are carrying a QR-enabled phone or tablet, we encourage you to scan the QR code on the right, which will bring you to the project-page of Dynamic Drawings from where you can access all visualizations.

We are indebted to Eric Jorink (HI) for his suggestions for the Swammerdam casus. Finally, we wish to thank the KNAW for funding and in particular we are grateful to Herman Pabbruwe, Director of Brill Publishers, who contributed generously with substantial, additional financial support and through making personnel available to the project and who followed its progress with enthusiasm.

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# Table of Contents

## Dynamic Drawings in Enhanced Publications

### PART 1: THE DEVELOPMENT OF DYNAMIC DRAWINGS IN ENHANCED PUBLICATIONS

I-1: Introduction .......................................................................................................................................................... 6  
I-2: Digital enrichments: towards a typology ........................................................................................................ 7  
I-3: Where to link from? Linking enrichment with publications ................................................................. 16  
I-4: Changing the point of view: enrichment in a user scenario ........................................................................ 18  
  I-4-1: The astrolabe casus as a self-contained enrichment ............................................................................. 19  
I-5: Discussion: working out the five other cases ............................................................................................. 25  
  I-5-1: Descartes’ refraction ............................................................................................................................... 25  
  I-5-2: Swammerdam’s microscopic drawings ................................................................................................ 26  
  I-5-3: Fortification .............................................................................................................................................. 26  
  I-5-4: Surveying ............................................................................................................................................... 27  
  I-5-5: Ramelli’s mill model ............................................................................................................................... 28  
I-6: Dynamic Drawings: Publication extensions or stand-alone publications? .............................................. 30  

### PART II: ARCHIVING DYNAMIC DRAWINGS IN ENHANCED PUBLICATIONS

II-1: Introduction .................................................................................................................................................... 32  
II-2: Toward a workflow of archiving interactive 3D visualizations ............................................................... 32  
  II-2-1: Selection ................................................................................................................................................... 32  
  II-2-2: Formatting ................................................................................................................................................ 33  
  II-2-3: Documentation ...................................................................................................................................... 34  
  II-2-4: Depositing ............................................................................................................................................. 34  
  II-2-5: Validation ............................................................................................................................................... 35  
  II-2-6: Publication and Access ....................................................................................................................... 35  
  II-2-7: Preservation .......................................................................................................................................... 36  
  II-2-8: Citation .................................................................................................................................................. 37  
  II-2-9: Discovery ............................................................................................................................................. 37
II-3: Archiving Interactive 3D Visualizations : Conclusion

PART III: POTENTIAL BUSINESS MODELS OF DYNAMIC DRAWINGS IN ENHANCED PUBLICATIONS

III-1: Introduction

III-2: Possible workflows & technical implications

III-3: Conclusion

CONCLUSION

APPENDIX: PUBLICATIONS AND PRESENTATIONS
Dynamic Drawings in Enhanced Publications
Report

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I-1: Introduction

Digital media are by no means new to scholarship. Where traditional, paper publishing soon experiences limitations once complex processes need to be visualized, the web offers nearly endless possibilities in presenting interactive, animated, and dynamical content. Yet, the fundamentally different ‘biology’ of web content makes its integration into the established publishing processes troublesome. Over the past decades, authors and publishers have explored digital means to offer additional, often ‘raw’, data as an extra to their (more articulate) papers and journals – either as CD-ROMs, open or screened off parts of journal websites, or as ‘teasers’ for promotional purposes. The core of scholarly practice, nevertheless, has not changed face because of these developments. Peer reviewing, authorship, journal ranking, or preservation issues remain concepts associated with the traditional paper media. Initiatives to extend these to the digital world are not seldom met with reluctance, as if they would challenge established practices.

On the other hand, researchers have to deal with a growing range of data and sources, and increasingly call for methods for contextualization and publication of such sources. There is a growing demand for hybrid products, and for corresponding new business models. And while it cannot be denied that solutions for this are being sought and important steps are being made, these mainly remain reserved for researchers in the exact sciences. For the humanities, where the ‘fuzziness’ of the source data leans itself less easily for categorization, the need is more urgent. Furthermore, (governmental) research financiers increasingly pose the condition of open access disclosure for research-related data and conclusions. Finally, publishers as well are aware that they have to reconsider their publishing practices and business models in these new open-access research environments. There is a demand for broader use and re-use of research content – the traditional image of the target audience is shifting.

Acknowledging a genre of scholarly multimedia – critical and interpretative, rather than merely creative [cf. Burgess & Hamming, ‘New Media in the Academy’, 2011], and examining how this, particularly for the humanities, can be integrated (complementary) (in)to the traditional publishing processes therefore seems a logical step. It should however be clear that this cannot be attempted without facing the already mentioned different ‘biology’ of digital content. Original authorship, product demarcation and referencing, product ‘completion’ or version control, etc. are issues paramount to bringing digital scholarly content in line with its printed counterpart. Equally important are technological aspects such as data persistency, link persistency (especially when print and digital are mutually referenced), architecture and application dependency. Evidently, bringing about a general solution for these issues is not accomplished in a single, short-term project.

In the KNAW-PPP project Dynamic Drawings in Enhanced Publications we decided to focus on the following questions:

Can digital visualizations add to our understanding of descriptions of technical operations and mechanisms, omnipresent in the corpus of printed historical science and technology treatises?
If so, what are the criteria for the linking architecture between the two representations, how should the enrichment be presented to the user?

How can such digital enrichments be made archived in a sustainable way for re-use?

Is it possible to develop new business-models around the re-use of enriched publications?

To avoid losing grips on the subject, we therefore expressly decided to work towards concrete goals and deliverables, by means of a selection of six cases from the history of science and technology. The choice for topics from this specific field allowed us to start up the creation of digital content quickly, as the cases mainly deal with (at a first glance) easily translatable machines, mechanisms and processes, while still being part of a historical tradition: the sources should be interpreted as elements within a broader cultural-historical story. They belong to the humanities rather than the exact sciences.

The eventual goal we had in mind was a concrete reference from each of these sources to newly created, persistent digital enrichments. By envisaging this – admittedly concrete - result, we were confident that any unforeseen issues would come forward, while still preserving enough room for pragmatic solutions would these be deemed necessary.

In the following paragraphs, our experiences in working towards this goal are set out. Nonetheless the scale of the project required the steps to be taken manageable, the working method proved to consist of rather distinct parts: the analysis of source material and creation of enrichments could for most of the time be carried out in parallel with the research and implementation on architecture and persistency. Therefore, these two subcomponents will be discussed separately.

I-2: Digital enrichments: towards a typology

The first phase of the project entailed an exploration of the source material, primary and secondary, where the digital enrichments would be based upon. Next to getting acquainted with the base material, this allowed us to get an idea of the variety in knowledge representations in the diverse fields that make up the early history of science and technology. This diversity in subjects was important for the pilot project’s goal of delving in the issues surrounding enrichment more generically. Thus, rather straightforward representations were selected as well as more complex ones.

Diversity not only arose in the representations’ complexities – some fields (e.g. biology/natural history) also indicated that the common (mostly mechanical) modeling tools might be less suitable for certain materials and fields of knowledge. In order to explore this further, and investigate any problem that this might bring forward, it was decided that the selection should also be rich in the variety of knowledge disciplines. Life sciences, optics, etc. were deemed desirable in addition to the more common ’mechanical’ topics.

In short, what we were working towards was a (pragmatic) typology of knowledge representations that could guide us in making a varied selection of representations on which the enrichments would be based. For example, one other feature that came forward was the ‘dimensionality’, both of the (original) image as of the idea it intends to represent. The suitability for creating truly interactive enrichments also varied from case to case, and here again we eventually wanted to have a broad
spectrum of cases at our disposal – from the purely demonstrative to the interactive. Finally, there were less intrinsic aspects that influenced our choices: source material for the different cases preferably was available in English, appealed to more than a handful of scholars (re-use criterion), and included selections from the holdings of Brill Academic Publishers, matching partner in the project.

The above considerations led to the following shortlist of cases to be considered for enrichment

<table>
<thead>
<tr>
<th>Name</th>
<th>Discipline</th>
<th>Interactive</th>
<th>Dimensionality</th>
<th>English</th>
<th>Brill-source</th>
<th>Re-use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astrolabe</td>
<td>Astronomy</td>
<td>**</td>
<td>2D/3D</td>
<td>Possible</td>
<td>Yes</td>
<td>**</td>
</tr>
<tr>
<td>Triangulation</td>
<td>Geometry</td>
<td>**</td>
<td>2D/3D</td>
<td>Possible</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Fortification</td>
<td>Geometry</td>
<td></td>
<td>2D/3D</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mill model Ramelli</td>
<td>Mechanics</td>
<td>*</td>
<td>3D</td>
<td>Yes</td>
<td>Yes</td>
<td>*</td>
</tr>
<tr>
<td>Refraction Descartes</td>
<td>Optics</td>
<td>*</td>
<td>2D/3D</td>
<td>Yes</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Microscopy</td>
<td>Biology</td>
<td></td>
<td>2D</td>
<td>?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Archimedes principle</td>
<td>Physics</td>
<td>*</td>
<td>3D</td>
<td>Yes</td>
<td>Yes</td>
<td>**</td>
</tr>
<tr>
<td>Pendulum Huygens</td>
<td>Physics</td>
<td>*</td>
<td>3D</td>
<td>?</td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>Huygens ocular</td>
<td>Optics</td>
<td></td>
<td>3D</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Waterpump Genneté</td>
<td>Hydrostatic</td>
<td></td>
<td>3D</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Vis Viva experiment</td>
<td>Mechanics</td>
<td></td>
<td>2D/3D</td>
<td>Yes</td>
<td>Yes</td>
<td>*</td>
</tr>
</tbody>
</table>

At the same time, it was decided that the enrichments would be worked out simultaneously and in iterations, rather than developing each case one after another. The reason for this was primarily to ensure a balanced distribution of time and resources to each of the cases: with seemingly endless possibilities of adding functionality, the risk of running out of time once the later cases are being dealt with, was not unthinkable. In addition, this parallel approach would allow us to gradually incorporate experiences from one case into the development of others.

As the project entailed a critical exploration of the mechanisms behind digital enrichments, rather than striving for quantity, the number of cases needed to be further reduced. With the desired diversity in mind, our final selection was decided to contain the following cases:

- **Astrolabe**: the archetype of the scientific instrument, this *object de vertu* forms a two-dimensional model of the motions of the heavens. It was said to solve 1001 problems, yet its workings needed to be explained in lengthy and complex treatises. A promising case for exploring the possibilities of digital drawings as a complement to static (time domain) and inherently two-dimensional original sources.
- **Refraction**: Several decades before Newton announced his colour theory, René Descartes already proposed a physical model for light refraction within his all-encompassing mechanistic worldview. Though later falsified, the model was advanced enough to successfully and quantitatively explain the appearance of the rainbow. A case in which an opto-physical model, originally described with text and images, will be translated into an animated visualization. Also interesting in the light of visualizing an ‘incorrect’ theory.

-Mechanical model of refraction in Descartes’ ‘Les Météores’ (1637).

René Descartes (translation J.H. Glazemaker), Proeven der Wysbegeerte (Amsterdam: Jan Rieuwertsz, 1659)

- **Swammerdam’s microscopic drawings**: Swammerdam’s drawings of insect anatomy were revolutionary not only in their realistic representations, but also in their sequenced, ‘film
strip’-like *kontinuierende Darstellung* of the creature’s development. Yet, in the light of 17th-century natural history, the author’s principal aim was to highlight the *analogous* development, in corresponding stages, of both the higher and the lower animal species. A digital enrichment could focus on this particular aspect of Swammerdam’s visual data, making a more critical examination possible. Furthermore, this case is interesting in utilizing the visualization for a biological concept that is quite distinct from the mechanical/physical concepts that at first sight appear more suitable for digital modeling.

*Insect development in Jan Swammerdam, Bybel der Natuure (Leiden: Van der Aa, 1737).*

- **Surveying/Triangulation:** This casus zooms in on the Early Modern tradition of surveying treatises, which gave an instruction in the practical procedures and the associated mathematics and instruments. For this casus it was anticipated that interactivity could be further explored.

- **Fortification**: Early modern science attempted to tackle real-life problems with applied mathematics. The dozens of fortifications and fortified cities, built in this period on mathematical grounds, are likely the most conspicuous remnants of this approach. The conditions that gave shape to this tradition eventually dictated highly specialized fortification designs. Where the subsequent stages of this development can normally be evaluated from maps and extant (later adapted) cities, this historic ‘optimization’ process of fortification building provides some interesting possibilities for digital and quantitative modeling.

![Fortification design in Simon Stevin, De Sterctenbouwing](Leiden: Van Ravelenghien, 1594).

- **Mill model Ramelli**: Agostino Ramelli’s *Le diverse et artificiose machine* (1588) was a highlight in the Renaissance *Theatrum Machinarum* tradition. In these treatises, examples were set out of how the elementary ‘simple machines’ (lever, wedge, etc.) could be combined into impressive compound machines, with capabilities sometimes exceeding the limitations of everyday technology. These illustrated works provide a fascinating view of Early Modern technology interspersed with Renaissance imagination. Starting from the original engraving and its explanatory text, the question will be what extra information is needed for – and what is the added value of – making the mill ‘work’ with digital tools.
With this list at our disposal, the following step consisted in creating storyboards for each of the six animations. Here, another typological aspect came to the foreground.

Knowledge can be represented in several ways. In a similar way in which an image, published in a `conventional’ source, is a different type of knowledge representation than the text it accompanies, a digital enrichment to this source will present its content via different ways as well. Each representation form has its own particulars, making it advantageous or disadvantageous for particular needs. This translation between representation mechanisms, e.g. from original to visualization or animation, is central to the process of enrichment.

Let us start with the source representation. The most common mechanism for knowledge rendition will likely be text. One of the particular properties of text is its being linear, i.e. it is well suited for representing chronological or other one-dimensional story lines. For the situations where this one-dimensionality is seen as a limitation, solutions have been proposed. Hypertext is such a form, and it can be argued that footnotes already offered similar functionality early on in the history of printing. Another traditional representation form is the image, whether or not as an addition to a text. The image obviously allows for non-textual, graphical representation, though in its traditional form it is essentially two-dimensional and static. And although images likely won’t fall out of grace for knowledge rendition soon, specialized adaptations have been worked out to (partly) overcome specific issues. In a number of cases, such solutions have become accepted as a media standard in its own right, e.g. moving image. Though this is not the right place to discuss all these representation forms, one more type of representation should briefly be noted here because of its relevance to one of the cases: the (mathematical) formula. Certain knowledge can very well be described in the
language of mathematics. This representation form entails specialized, efficient method to describe the behaviour of e.g. natural laws or physical systems. Its advantages include compactness and, if desired, unlimited dimensionality and complexity. Within the discussion here, it is worthwhile to note that this form is just one specific type of representation tailored to a need that has proven to exist. Knowledge renditions are adopted because of a specific need that arises. In earlier sources, instances can be found of authors exploring the limits of available representations because their subject matter calls for it. In other cases, the means available worked out just fine.

Examples of purposefully chosen representations: Text interspersed with images in Descartes’ Les Météores (left) and 'enhanced' two-dimensional anatomy with fold-out plates (right).

When we, now, intend to enrich a given source by means of new (digital) mechanisms that are nowadays available, a different representation will be the outcome - be it slightly upgraded, rewritten, or perhaps only partially interpreted and enhanced. A process of interpretation and translation will have been applied in generating the eventual outcome. In some instances this translation process may be more or less dictated by the (limits of the) original representation - the process appearing nearly trivial. For example, an early source in which states of an object over distinct periods of time are represented in a sequential manner - Swammerdam’s insect development for instance, but drawings of comets would also apply - it speaks for itself to add this time variable in the subsequent visualization, yielding a 'film', a representation familiar to a modern reader. In other cases, this translation process may be more complex, and therefore perhaps less easily ignored. If we want to take advantage of the possibilities of adding interactivity to a digital enrichment for example, more decisive and subjective choices need to be made in translating the original representation into an enriched variant. Here, it may be necessary to further interpret the original source, or to consult secondary literature in order to make sure the enrichment is developed correctly. In either case, translating a knowledge rendition into an enriched representation always implies an 'interpretation layer' in which mappings are made, variants are considered, and often additional content and context is integrated as well.

The inevitability of such an intermediary interpretation layer soon became evident in our enrichment process. That a well-considered storyboard would be necessary for the more ambitious cases was
anticipated, but to our surprise even the most straightforward casus soon demanded such choices to be made. Such was the case with Swammerdam’s microscopic drawings. Our intention was to use digital means to make a side-by-side comparison of Swammerdam’s drawings easier. The author originally had published plates for a handful of insects and higher animal species, each one showing the specific organism’s development in six distinct stages. Yet the goal of Swammerdam’s treatise was to highlight the analogy in development for all these seemingly different creatures. This in turn supported his theological stance that God’s creation can be admired in all species, orders high and low, and attacking the prevailing concept of ‘spontaneous generation’.


In discussing the enrichment opportunities it seemed clear that we could make Swammerdam’s goal of comparing the different species easier. The enrichment was set up as a one by one comparison of two selected plates, with a slider moving both representations through their successive development stages. But how far could we go in reworking Swammerdam’s drawings into a (visually) continuous development? It is remarkable to realize how straightforward Swammerdam’s sequential drawings look to a modern reader – conditioned to moving image – while in their time of publication they were truly innovative. Thus it is tempting to fill in the ‘missing’ parts in Swammerdam’s representation with reconstructed intermediate steps. In our case, the possibilities ranged from integrating the six drawings just as they were, up to modeling the organisms from the drawings in
three dimensions and molding a large number of stills from this into a continuous film. Eventually we decided to go for a compromise. For each series we chose to blend the six successive stages from the original drawings over into each other. To a modern reader, this enhanced the perception of continuity to a large extent, while not corrupting the original data and aesthetics too much.

The previous consideration illustrates well how even the – at first sight – most trivial enrichment case require additional information and expertise in order to decide when content is to be enriched, that is, when one knowledge representation is to be translated into another type.

For the six cases we have been working on this can be made more explicit. All the cases have in common that they are topics from the history of the natural sciences. Original material – textual, visual, etc. – is being interpreted, and in all cases additional evaluations, interpretations or sources are taken into account in deciding on the most suitable enrichment strategy. That is, use is being made of contextualization of the original sources. As, next to the primary content, this context is an ingredient for the enrichment process as well, it may even be stated that it is the ensemble of ‘raw’ content and additional context that defines the input for our workflow.

This allows us to sketch a more generic model of the elements that constitute the enrichment process:

A deconstructed model of [the workflow of] publication enrichment
I-3: Where to link from? Linking enrichment with publications

Now that the particulars of representations in original sources, and the complexities in their relation to the enrichments have been made explicit, it is worthwhile to consider what the implications are for the link that should connect the two.

Firstly, the diversity in representation types, and the possibilities in interpretation freedom, imply that a preferential location to (physically) place the starting point of the link might not always be present. For example, in case a short linear piece of text is being translated, quite literally, into an animated enrichment, it is rather straightforward to refer to the enrichment (by means of a hyperlink, QR code, ...) simply in the margin. For an illustration that is used as a basis for enrichment, the same applies. The starting point for the link is clearly localized in the original source. But it can be different altogether. If we synthesize the enrichment from a set of distinct excerpts in the source, a (clearly localized) one-to-one relation between source and enrichment is no longer present. A similar situation arises when the entire content of a chapter, article or book is ‘summarized’ into an enrichment. In a sense, the translation layer becomes a transformation of the input data. For the physical link, it implies that the starting point in the original source is ‘spread out’, be it over distinct excerpts or over the work as a whole. While this may be mainly a technical issue, it is something that should (and can) be dealt with when digital enrichment is adopted in the publishing workflow. For instance, if the source excerpts are clearly localized, links can be put in the margin – but for other cases a physical link at the beginning of the article, chapter, or even on the title page of a book may be more appropriate.

Three scenarios, from clearly delimited to more distributed, of input localization. Each one requires a specific approach for (physically) linking to the enrichment.

While the previous consideration dealt with the relation between source material and enrichment (as embodied physically in the hyperlink/QR code/...), a similar situation holds for the relation with external material. Here, the practical consequences for the publishing branch are more far-reaching: this because a) the external material (‘context’), that in one way or another is consulted for creating the enrichment, does not form an intrinsic part of the two ‘core’ enrichment entities: (primary) source and (digital) target. And b) because this external material is not clearly demarcated.
In the previous paragraph – there illustrated with the choices that came forward when putting together the Swammerdam storyboard – it was argued that very soon in the interpretation process, context in the form of external material comes along in tailoring the primary data into an enrichment scenario. In that specific case, Swammerdam’s notion of parallel development was given a central place in the enrichment scenario, rather than other intrinsic aspects of Swammerdam’s original publication (other choices could have included aesthetic aspects, faithfulness to life of Swammerdam’s drawings, ...). The choice we made was governed by recent studies on Swammerdam [Jorink, *Reading the Book of Nature*, 2010; Jorink, ’Beyond the lines of Apelles’, 2011], where these aspects of his work were critically reviewed and placed into their 17th-century background. Thus, our general model of enrichment workflow (previous chapter) can here be filled in as follows:

**Storyboard with basic architectural features of enriched publications. Casus Swammerdam**

If we now attempt to implement this specific model into a linking framework for enriched publication, the problems that have been mentioned can be phrased as follows: a) where, in the path from source to enrichment, should we place the context material? Other than with internal references in the source, the secondary literature consists of materially distinct codices, ‘isolated’ from the source as no references exist from the latter to the former. The context material contributes to the enrichment, but is easily missed out if it is not integrated in the linking framework. Should we still place it on the left hand of the diagram, where source material logically resides, or rather present it along with the enrichment, on the right hand of the diagram, where linking to
external sources is more practical? And b) how far should `contextualization' go? What works should be included in the list, and which shouldn’t? In practice this won’t pose too much of a problem, it can be arbitrarily decided – for example by taking into account the target audience and assuming what foreknowledge is present. Yet the point here is that in terms of enrichment methodology the contextualizing input material is not a closed, clearly delineated data set.

I-4: Changing the point of view: enrichment in a user scenario

Up to this point in the project, we had been working rather loyally along the goals that were stated when we set off: the selected cases for this pilot project would learn us how the content matter of historical scientific sources can be digitally visualized, elucidated/clarified, referenced, and preserved in a sustainable manner. In a sense, the way this prospect is described starts from the assumption that the experience of enrichment always begins with the primary source, the enrichment only coming along at a later stage. That is, one easily assumes a direction vector in the usage process `enrichment’. But this needs not necessarily be the case.

During the project, we experienced this once the workflow model was presented and being discussed. While the model had been set up to illustrate the process of developing an enrichment, from source material via context towards the final product, it appeared that the same model wouldn’t be too bad after all for a usage case, in which an end user first gets acquainted with the content matter through the (more engaging) digital enrichment, only to delve deeper into the (`rawer’) source material in a subsequent stage. In the course, the end user gets his way through the translation process, in the meantime coming across the extra context material that has been used. The direction vector then runs from the right hand to the left hand of the diagram. Important to note however, is that this puts other requirements on the enrichment. As this entity gives the first introduction to the content matter, hardly any foreknowledge can be assumed and the enrichment should be self-explanatory – while in the earlier scenario (source to enrichment), the enrichment can essentially remain limited to the added value that builds upon the information already present in the source publication.

In a sense, this change of perspective mimics the focus on target audience that we already came across, when discussing the decisions leading to our particular implementation of the Swammerdam case. There, we saw that even for the slightest interpretation step, while transforming one knowledge representation into another, aspects such as target audience and assumed foreknowledge come in to play.

Therefore, when discussing the possible angles of perspective of the enrichment model, we felt that the target audience, `unavoidable’ an aspect it again proved to be, could not be merely neglected. The usage case in which the enrichment serves as the primary portal to the content matter, deserved further attention. But on the other hand the creation of six `complete’, self-explanatory enrichments would significantly alter our project’s goals and time scheme. It was therefore decided to work out one case – the most promising for the purpose – as a complete stand-alone application, and leave the other five as originally envisaged: complementary to the primary source material.
As was mentioned when we introduced the final selection of cases, the astrolabe is a scientific instrument that gives a two-dimensional model of the earth, and the heavens revolving around it.


It was selected as casus, because the working principle of the instrument quickly become cumbersome when being described in 2-dimensional, static (textual) representation. The possibilities in terms of enrichment are therefore extensive. Yet, when introducing (pictures of) this instrument in the project group, the mysterious elegance of instrument soon led to the question `what is it’?

Primary source material, available as a starting point for the enrichment, told all the technical specifics in detail. But sketching the instrument’s story includes its background, prehistory, impact and centres of manufacture as well. Within our limited setting, a need arose for a summarized introduction to the instrument, including its historical context.

Furthermore, experience in an earlier educational project on the history of science, by one of the team members, had shown that the astrolabe was a popular topic for pupils and students to work
out as an assignment. Perhaps the puzzling aesthetics of the instrument, combined with its nearly millennium-long usage tradition spanning several cultures, and its clever application of solid geometry, made it a very suitable casus for studying both the internal and contextual developments in the history of science. Among our six selected topics, it was a casus with a large re-use potential.

This potential is not to be underestimated in the actual implementation of digital enrichment in the publication workflow. While a highly specialized, expert topic may lend itself perfectly well for enrichment, in reality a severely limited target audience may make a custom-made enrichment an expensive exercise. When this target group can be extended – either by making the enrichment applicable to more enrichment cases (sources) or by making the enrichment less dependent on the expert material – the choice for enrichment can easier be justified. By consequence, from a business perspective there will be a tendency towards more ‘generic’ enrichments and tools to produce them more economically. The interpretation process, from one to another knowledge representation, will in these cases likely be more prominent: more steps are taken to transform the ‘raw’ source material into an accessible or versatile enrichment.

Creating a stand-alone enrichment for a non-expert audience requires a structured approach. In devising the storyboard for the astrolabe enrichment, one consideration that arose was the ideal ‘engagement’ that could be expected from the target audience. How much freedom of movement should we give the user during his exploration of the content matter? It may seem best practice to keep the storyline firmly in hand, making all the choices in advance and presenting the user an entirely finished story without any room for intervention. Yet, the more active end user will immediately be bored with such an approach, desiring to pull the strings himself. In a similar vein, when it is being deployed for demonstration as part of education, it is often desirable to transfer the direction/control of the enrichment to the teacher, allowing to elaborate where needed and adapt the pace of the story to the specific audience. Finally, a stand-alone enrichment (perhaps in this situation better termed ‘application’) should also offer a route to the source material the storyboard is built upon. In a sense, such a layer would be the form of presentation with an extreme level of freedom of movement: the source material is presented without any further contextualization or mutual references.

In adapting these different layers to the astrolabe application, we found great help in a model developed by the Web studio Terra Incognita, the “integrated online exhibit model” [Marable, 'Experience, Learning, and research: Coordinating the Multiple Roles of on-line Exhibitions', 2004]. This model aims to structure the possible storyboard approaches, from highly engaging, narrative-driven up to the ‘research’ level where the material is presented in an almost bare form. Further details can be found in the diagram below.
Translating this to the astrolabe case led to a storyboard in three parts, correspondingly called the ‘experience’, ‘exhibit’ and ‘research’-layer. We will begin here with the experience layer. While the Terra Incognita model appropriately notes that all three layers can serve as entry point to the content, for the novice user the introduction will commonly take place by means of this experience layer. For the astrolabe case, we have attempted to use this layer to answer the question “what is it?”. The working principle and possible uses of the instrument are concisely explained, after which the usage and production tradition is situated in its historical context. In our case, part of the graphical content used for making this layer consisted of (still) images, pictures or engravings, while
for the other part use was made of ‘pre-programmed’ animations of the astrolabe/universe models that had already been made for the exhibit-layer, discussed hereafter.

The exhibit layer allows for a higher level of interactivity, and therefore loses much of its linear character. The user is left to explore functions that have been built in by the designer. The presented information is curated, but not with the strict constraints (and ease) as with the experience layer. For our case, this was the opportunity to work out the real added value of digital enrichment. The representation of the heavens that the instrument embodies, often so cumbersomely set out in textual sources, could here fully be ‘built’ as a comparative physical model for the user to experiment with. As such, the user can ‘manipulate’ and employ a virtual astrolabe, while at the same a rendering of the earth, observer, moon and heavens moves along with the manoeuvres the user is carrying out. This form of presentation is particularly suited for users who already have some working knowledge of the astrolabe (after having gone through the introductory experience layer for instance), users who prefer to get acquainted with the instrument in a ‘hands-on’-fashion, users who wish to solve a specific problem with the instrument, or teachers who need to fit in the application in an already existing tutorial.

In addition, we created a second part of exhibit layer in which instructions are given on how a specific problem (in this case finding the time by measuring and processing solar altitude) can be solved. This is done in a step-by step scheme – without, however, having the actual operations carried out by the program; this is demanded from the user. As such, this exercise also shows a relatively high degree of interactivity, and is therefore included in the exhibit layer.

As for the third layer, the ‘research’ level, we were a bit in doubt whether in our specific situation it would be practical to have all this source material included – embedded – in the application. After all, we already had a logical location for this ‘raw’ material. The issue mainly arose because this type of material, scans of books and high-resolution instrument photos, would considerably blow up the file size of the application, affecting load time and applicability of the enrichment. On the other hand, it is not difficult to state what this research layer would have to be composed of: the raw, ‘uncurated’ source material on which the application is based, possibly combined with a viewing interface that facilitates in-depth inspection of these sources.

Finally, it is noteworthy to mention that another aspect present in the Terra Incognita model has not been implemented in our application: the “connecting storylines”. These run through the different layers of the model, and allow the user to ‘branch off’, to continue his story at a higher or lower level of engagement at points where this is applicable. The reason for this had mostly to do with available time and resources - in a more advanced version of our astrolabe model it could equally well have been included.
By building the astrolabe enrichment specifically as a stand-alone application – accessible from a point of entry other than the source material – we also gained some experience on the differences in resources that such an approach demands. As had been set out before, we deliberately chose to explore this audience-centered model only for one enrichment, as this goal had not been stated explicitly among the points of departure of the project. We felt that it was worth a closer look, but not for all the cases. But, does devising a ‘layered’ enrichment, suitable for multiple audiences, really demand so much more effort?

On the one hand, we were quite optimistic about this. Creating a stand-alone application requires much more in terms of storyboard, but somehow a portion of this content will always be overlapping – we anticipated that quite some re-use was possible. This indeed proved to be the case. As the screenshots show, we took advantage of the fact that the physical model that links the astrolabe parts to the celestial motions, was there to put to use. This model – which required quite some ‘invisible’ programming and mathematics – had been created for the ‘exhibit’ layer, and would have been the core of the enrichment even when not specifically targeted towards a general audience. Now that an ‘experience’ layer needed to be made, we simply could fit this model into the scenario, programming the motions of instrument parts and planets in correspondence with the story being told, and thus removing the interactive aspects of the model in this specific narrative-central presentation type.

On the other hand, we did experience that writing a specific storyboard for a layered, stand-alone enrichment application does involve extra time and resources. For the experience layer, while the astrolabe model could be re-used, most of the other information had to be delved up or written from scratch. In particular, image material elucidating the contextual background of the matter (in our case: paintings depicting collections with astrolabes, city views of centres of manufacture, etc.), including the usage rights, had to be arranged. Also, writing the text for the experience narrative involved quite some editorial work. And finally, with respect to the navigation throughout the application in general, and within the more interactive content in the exhibit layer in particular, we experienced that extra programming work exists in ‘demarcating’ the user’s freedom of movement: not only should be implemented what should happen when the user takes the expected, intended steps – but effort should also be put in avoiding strange things to happen when the user decides to put the unintended functionality of the application to the test. This ‘error handling’ involves an increasing amount of resources the more complex the interactivity of the application grows. And as multi-layered, stand-alone enrichments generally are more complex than a simple, monolithic enrichment, this is something to be prepared for.

In hindsight, we therefore would conclude that, while some overlap exists and smart re-use of some content is in itself attractive, the creation of a layered, stand-alone application suitable for multiple audience types does involve extra steps. As regards to content, these extra steps mainly have to do with the narrative of the presentation. In terms of programming, particular emphasis should be put on creating a coherent, bug-free interactive user environment.

I-5: Discussion: working out the five other cases
The astrolabe casus was chosen to explore the creation of a particularly audience-targeted enrichment, but notwithstanding this, the other five cases also required appropriate choices to be made in terms of interactivity, adherence to the source, etc. – i.e. translation to a new knowledge representation. The issues involved have been set out earlier in this document, here we will briefly discuss how the five cases have practically been worked out.

I-5-1: Descartes’ refraction

In this casus, we have attempted to elucidate a physical model for light refraction proposed by René Descartes, by means of which he successfully gave a quantitative derivation of the appearance of the rainbow – notwithstanding that his mechanical refraction model was soon proven ‘wrong’. The basis for this enrichment was the textual/diagrammatical description of this process in Descartes ‘Les Météores’. The goal of the enrichment was to adhere as strictly as possible to the original source, and create a ‘demonstrator’: an enrichment lacking any interactivity, following the original (linear) narrative, and – as for the strategy to attain clarification, i.e. the added value – purely making use of the dynamics that digital animation has to offer.

One of the problems we encountered had to do with underdetermination. We initially assumed that the model Descartes offers is complete: that every aspect that matters to his argument will be accounted for in the text, yielding a coherent physical model. Coherence definitely is what Descartes preaches in his writings, too. Yet closer reading – inevitable when an animation needs to be made – reveals that inclarities and inconsistencies remain. Regarding the inclarities: it is remarkable how easily we, as modern interpreters, fill in the gaps with current ‘facts’. For example, Descartes never explicitly states that his colour model is a ‘continuous’ one. His description hints at it, yet within 17th-century colour theory this cannot readily be assumed. Is it sure that Descartes doesn’t adopt a model of six or seven discrete colours? Probably it is, yet the point here is that interpretation comes into play, and we resort to current evidencies before we are fully aware. A similar situation arises for inconsistencies. For instance, in this refraction model Descartes assumes a finite speed of the light ‘particles’, while in other writings he holds on to instantaneous transmission of light. This inconsistency was also pointed out by his contemporary critics – yet for a modern enrichment-
builders like us this can lead to problems, especially when the inconsistencies are truly ‘internal’ to the model that is being used.

On the other hand, developing an enrichment makes it possible to critically review historic models like Descartes’, testing them by means of digital implementation. Sooner or later, discussions arise when the author has left us with ambiguities. In working out the refraction casus, it was particularly instructive to discuss possibilities in interpretation with members of the project team.

I-5-2: Swammerdam’s microscopic drawings

This casus has already been discussed earlier in this document, where it was presented as an illustration that even the, apparently, most straightforward translation of representations seems to involve choices, interpretation, and contextualization. Yet, acknowledging the choices that were made, we believe that the final enrichment serves its original goal quite well. The added value of the enrichment was the presented one-by-one comparison of the different species in similar development stages – a message that was fundamental to Swammerdam’s writings, but in visual presentation was somehow hindered by the material medium of fold-out plates.

A final experience to note in this respect, was the importance of ‘original appearance’ in the enrichment. In an initial stage of developing, we had ‘cleaned up’ the scans of Swammerdam’s drawings thoroughly, retaining only the greyscale engravings and ridding these from the distinctly 18th-century texture of the paper medium. Somehow, we felt that this was the ‘raw’ information at that stage. The engravings where subsequently presented on a rather sterile, white background. During an intermediate presentation of the project’s progress (NIAS, 21 March ‘13), we were advised by someone from the audience, however, to pay more attention to the ‘aesthetics’ of the source (NB: this remark was made for more than only the Swammerdam case). When we subsequently re-added some 18th-century ‘touch’ to the enrichment, we could only conclude that indeed a more attractive application emerged, with less ‘distance’ to the original source. Perhaps one could argue that we initially had too strict a conception of what the ‘source’ entails, and that material aspects of the original medium should not by definition be left out.

I-5-3: Fortification

This casus was immediately recognized as a candidate for a highly interactive enrichment, but somehow the exact scenario went through different incarnations before finally reaching its final form. This had much to do with the issue of following a source literally vs. borrowing ‘selectively’, or more abstractly, from a source. Not surprisingly, much of the preceding discussion about ‘localization’ in the source material took shape while developing this casus.

The source material the enrichment was to be based upon, was Simon Stevin’s ‘De Sterctenbouwing’ – an early modern treatise on fortification. The work introduces fortification design principles and sets out the variables that determine defensive and offensive strength, all treated in a well-structured manner. As such, the book lends itself very well as blueprint for advanced quantitative modeling in the enrichment. Yet, the variables were so many that a selection needed to be made,
and eventually we felt that the underlying message of the book, what we often referred to as ‘optimization’, could better be expressed by showing how this entire set of conditions gave shape to real-life fortifications and cities. One or two such variables still would be highlighted to show their impact – but not as part of a vast series of conditions, as the more determinative aspects would then soon be overlooked. Therefore, in the end the enrichment scenario took on a more narrative character, with ‘the ideal city’ as an underlying theme.

What we however did retain, was the usage of 3D-modeling as an added value to the original representation. All these considerations eventually led to a clearly structured, hardly interactive – yet dynamical and visually attractive enrichment.

Stills showing how the fortification narrative included models created in 3D. The enrichment can be accessed via http://persistent-identifier.nl/urn:nbn:nl:ui:13-lg28-gm.

I-5-4: Surveying

A casus that did lead to the interactive form that was initially envisaged, was the surveying casus. Source material was a surveying treatise written in the early 1600s, which provides a step-by-step instruction on measuring and mapping a piece of land, given certain specific conditions. This lent itself perfectly for a step-by-step tutorial in which the user is required to perform all these steps before he can proceed. The assignment ran as follows: determine the distance between two points A and B making use of surveying instruments. When devising the storyboard we decided to think up a ‘typical’ surveying situation, i.e. we allowed ourselves a bit of liberty in filling in the actual case. For instance, to anticipate on users who attempt to solve the problem in the most trivial way – walking to the site and placing a measuring rod between the two points – we placed an ‘untrespassable’ river between user and site, obliging him to use indirect measuring techniques.

A determination that needed to be made was the level of freedom to allow the user. The problem had to lead to the correct solution for arbitrary choices of reference points – as the technique dictates – but here we experienced that an infinite level of user freedom requires an exponentially growing effort in foreseeing and programming all the different scenarios. We therefore arrived at a
compromise between a too restricted (i.e. boring) usage space and an interactivity too complex to implement.

During development, an instructive thing to learn was the real role of mathematics in arriving at the solution. We realized that, once all the required steps are completed, the surveying problem is 'mathematically determined', i.e. all the information is present for expressing the distance that needed to be found. But when we actually sat down to perform the calculation, we found out that all these 'trivial' mathematical steps take even more time than the actual surveying operation itself! We then learned that, notwithstanding the mathematics being treated in these surveying instruction books, a far more popular technique in the 1600s was the measuring of this distance (to scale) on the map that meanwhile had been produced – in a sense 'omitting' all the difficult, but exact, calculations. Developing the enrichment in this case gave us a better understanding of 17th-century surveying practice.

I-5-5: Ramelli’s mill model

A somewhat untypical casus for enrichment was the mill model from Ramelli’s Le diverse et artificiosae machine. While being a mere mill depiction, the tradition it was published in makes that one cannot take for granted that the mechanism would actually function in real life. Testing this, and seeing which issues arise, is what we set out to do in the enrichment process. But, in addition, the material that we defined as source was not strictly Ramelli’s 1588 text and engraving, but a recently published historical-technical overview sketching the evolution of mill technology [Lawton, Various and Ingenious Machines, 2004], and using Ramelli’s model to illustrate what innovation took place.
around 1600. This secondary source is mainly textual, but does not refrain from using formulas from time to time.

And that is where it becomes interesting. The formulas, in print, may confuse a lay reader, but in the enrichment world they are precisely the ingredients that breathe life into static 3D models. Thus, we were able to implement this physical model into a virtual corn mill. As such, this source material forms an interesting case of knowledge representation. When discussing types and translations of such representations, earlier in this document, we already argued that primary material needs not necessarily be restricted to textual or graphical representations. In most such ‘traditional’ cases, enrichment ‘breaks down’ the structure, linear or dimensional, of the source description – and interactivity/dynamic behavior is added in the process. Here, one can argue that in the source formulas, the dynamic behavior is already present – they only have to be visualized.

The backbone of the enrichment we built was therefore a dynamic algorithm, driving the 3D mill which was modeled after the engravings, and taking input from five sliders that adjust the variables. It was very intriguing to see the virtual mill speed up once ‘wind’ was applied, and slowly spin down when the brake was pulled or the mill rotated.

Not that the modeling, leading to this, worked out without any difficulty. When closely studying the original engravings, we realized that Ramelli’s engraver had depicted the driving post excentric to the millstone. Further delving into mill designs showed, however, that this can never be the case in real mill constructions, so we decided to ‘correct’ this engraving flaw. In addition, close study of the drawing in general revealed that some exaggerations and omissions had been made in order to

Front panel allowing the user to operate the virtual corn mill. The enrichment can be accessed via http://persistent-identifier.nl/urn:nbn:nl:ui:13-ppdm-uv.
obtain a more dramatic perspective effect. The drawing looks like a real-life representation, but in fact this wasn’t entirely the case.

I-6: Dynamic Drawings: Publication extensions or stand-alone publications?

We started the discussion by introducing the primary sources on which the enrichments were to be based, and the opportunities that might enrichment offer. It was set out that each source offers a specific representation of knowledge, determined by characteristics such as linearity, dimensionality, etc. Instances where this representation form `obstructs’ a lucid rendition of the idea/process/mechanism seem to profit most from enrichment. Yet, these cases also demand more interpretation and therefore more specific knowledge, as the knowledge representation they will be translated into differs most from the original representation form. From this observation, we proposed a working model for enrichment, which acknowledges an interpretation/translation layer between source and enrichment, and which also makes room for extra contextualizing material that adds to the enrichment process. The specific case of Swammerdam’s microscopic drawings was put forward as an example to illustrate how even an apparently trivial enrichment case eventually shows to require these components. Later in the document, the development of the other enrichment cases was discussed, where similar aspects came forward. Enriching Descartes’ treatise on refraction compelled us to fill in the gaps, and decide on the inconsistencies in the model he originally presented. Other texts required us to summarize the original content in order to clarify the underlying message of a treatise, yielding a highly narrative enrichment. A surprising case was Ramelli’s mill model, where the mathematical description from the source text, a few adaptations left aside, allowed us to bring the model to life. Yet in all the scenario’s, interpretation and contextualization showed up.

Interpretation implies (subjective) choices, and thus it is not surprising that soon a target audience comes to mind when the enrichment storyboards are being written. In one instance, we took this idea further and approached the enrichment from a user perspective. The path then no longer runs from source to enrichment, but allows for the enrichment to serve as user portal. While this was not strictly foreseen in the project, we considered this scenario to be relevant enough, as material nowadays is increasingly ‘found’ via search engines. The question subsequently was how this poses different criteria for the enrichment content. We found that inverting the direction (source-enrichment) has its repercussions for the latter: one can no longer assume any foreknowledge from the user – therefore the enrichment needs to become a self-explanatory application. On the other hand, we found that frameworks dealing with this are readily available – and made use of one that furthermore tackles the differences in ‘engagement’ (linear vs. multi-dimensional narratives and static vs interactive) to be expected from the user. The ‘raw’ source material, as it figured before, is very well suited for a deeper ‘research’ layer in a user-oriented stand-alone application. That is, the model this project originally aimed at – enrichment that adds upon the original source material, which is consulted first – can very well be integrated with a more user-oriented, stand-alone approach of digital enrichments. Key to this is a layered approach of the application, where multiple points of entry provide for different user expectations.

Enrichments that show strict correspondence with an existing source text will in general be highly expert-oriented. Versatility of enrichments will in these cases be a consideration. This can be realized
by broadening the target audience, or by aiming at enrichment re-usability – making the enrichments more *generic* does not necessarily rule out their suitability for expert use. From a theoretical point of view, one can wonder if such a strict and objective correspondence between source and enrichment is even possible – as both are different types of knowledge representations. True transparency is difficult to hold on to in practical enrichment scenario’s, the least one can do is acknowledging and justifying the interpretation and contextualization aspects that sooner or later come forward in the process of enrichment. In that sense, digital enrichment needs not necessarily be different from classical scholarly publication: it can be critical, falsifiable and therefore a product of original scholarship.
II-1: Introduction

This part of the report describes how the enrichments can be archived by DANS as a data archive. The astrolabe is taken as a use case. This chapter discusses the contents of the enrichment and what needs to be preserved. Then it will focus on the question how the preservation meets the interests of both a publisher and a long-term preservation archive. These issues are grouped and categorized as “selection”, “formatting”, “documentation”, “depositing”, “validation”, “publication and access”, “preservation”, “citation” and “discovery”.

II-2: Toward a workflow of archiving interactive 3D visualizations

II-2-1: Selection

We need to determine who will want to use the visualization and to what purpose in order to determine what needs to be preserved. We define two scenarios:

1. A researcher reads a Brill-article about an Astrolabe that contains a link to the enrichment. The reader follows that link to see how an astrolabe works and do some simple experiments to test the working of the one.
2. A researcher wants to use the enrichment for e.g. teaching. The researcher asks a 3D developer to adapt the enrichment, e.g. by extending it with an alternative rete.

We decompose the visualization into the following:

- A means to explain readers the working of an astrolabe.
- A set of functional components that allow navigation through explanations of text and images, adjusting the parameters of the astrolabe, selecting a perspective and a concurrent animation of the configuration of the instrument and the corresponding state of the universe.
- Source-files that define the 3D model, text, images, animation and interaction.

For the first scenario it is important that all functional components of the enrichment are preserved and that these can be easily used by others, now and in the future. Worst case, an alternative enrichment can achieve the purpose of the enrichment. For the second scenario it is important that the source files can be easily interpreted, adjusted and transformed (or compiled) into a new visualization.
II-2-2: Formatting

The format determines whether the information can be interpreted by current or future software, as such it is important that data is using durable file formats.

DANS maintains a list of preferred file formats. This list contains file formats that are most likely to sustain due to the following qualities: usability, accessibility and robustness. The list of preferred formats does not yet contain formats for 3D data: There has not yet been any demand to archive 3D data and, after investigation, there are no 3D formats that meet all three qualities. The latter is an acknowledged problem in the world of digital archiving. The various software-packages implement their own features and formats. This causes conversions to lead to a loss of information. What measures can be taken to increase the durability and accessibility of the enrichments, or parts of it? We will look at the defined scenarios.

First we look at preserving the functional visualization: how can we ensure that the reader can consumer the enrichment in the future?. The enrichment is formatted as a .unity3d scene. It is a proprietary, closed format that is designed to protect potential proprietary data\(^1\). It can be viewed using the Unity-software package or using the Unity Web-player browser-plugin. Alternative formats for interactivity and animation that could increase the usability and robustness are Flash, Silverlight or HTML5. Unity does not support export to Silverlight (which is still proprietary but more widely adopted) or HTML5 (which aims to be more open). Unity’s support to export as Adobe Flash got removed recently (potentially because Adobe Flash is no longer supported by all browsers\(^2\)).

The closest preferred format-type for these scenes is video. This format does not support interactivity, but a screencast can demonstrate the different types of interactivity that exist in the scene.

*DANS recommends depositing the original format (.unity3d) and a screencast of the scene as MPEG-4 H264 video (.mp4). DANS should monitor the developments regarding interoperable 3D support and support by generic frameworks like HTML5.*

In order to allow a researcher to adapt and reuse the enrichment it is important to preserve the source files that define the 3D models, the texts, images, animation and interaction. We look at the formats for the different information that is stored:

**3D Model definition.** Unity stores these as Wavefront Object- and Material files (.obj and .mtl), which is a good preservation format for 3D spatial models. Wavefront Objects do not store any information regarding animation or interactivity.

**Text definition.** We found the texts of the interface and explanations within a .unity-file (\ Assets\Scenes\Main.unity). We were not able to find documentation on this format. Should it be desirable to store text definition for long-term preservation or accessibility, it is recommended to define or extract these in a separate ASCII (UTF-8) text file.

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\(^1\) Description of Unity3D file extension at FileInfo.com. [http://www.fileinfo.com/extension/unity3d](http://www.fileinfo.com/extension/unity3d)

**Image / texture definition.** These are stored as JPEG, PNG and PSD. JPEG and PNG are on the list of preferred formats. We recommend converting the PSD to the preferred format for images: JPEG (for accessibility) and TIFF (for long-term preservation).

**Animation and interaction definition.** These are defined as .NET C# (.cs) files. C# is a widely adopted programming language, and unity uses the tools from the open source project Mono to interpret these. However, DANS cannot yet commit itself to the complex task of software preservation.

The options to preserve interactive 3D models are limited because there exist no preferred formats for them. A small number of formats score reasonably well for important characteristics for long-term preservation and access: COLLADA (.dae), Autodesk FBX and X3D. Out of these options, the COLLADA format has the preference of DANS as an open-source alternative that would store animation and interactivity besides the 3D model. COLLADA, managed by the Khronos Group, defines an open standard XML schema for exchanging digital assets³. FBX however is the most current and widely supported format. The developer tools from this project do no support an export to such formats. A requirement for such formats would pose limitations for the workflow and/or software that are used by the developer. A lack of best practices for such workflows makes it unrealistic to require that.

*DANS recommends depositing the original source files, where the PSD files are first converted to JPEG. In addition, DANS recommends making an export of the project to COLLADA and to FBX. Best practices are needed before such formats can be required.*

**II-2-3: Documentation**

The documentation describe how the files and folders are organized. They should explain to the so-called⁴ designated community how they can use the data: how can a researchers / reader from Brill recover and play the scenes and how can a developer reuse the source files in a new interactive / 3D project in order to create a new scene?

*DANS recommends adding a text-file (UTF-8) or PDF file that describes how to open- and play the scene-file and how a developer can open the source files into a 3D-development environment.*

**II-2-4: Depositing**

Depositing the enrichment to the archive of DANS implies transferring the data, providing metadata, choosing a collection and agreeing with the licenses of DANS. The former two aspects did not pose any challenges within this project. The best collection for the enrichments that DANS currently

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⁴ Reference Model for Open Archival Information Systems (OAIS)
provides is history\(^5\), as there is not yet a collection for history of science. The license agreement is more interesting, as it is entered between DANS and the one who deposits the data.

The question is whether this should be the publisher, the researcher of the developer. On the one hand this is whoever holds the rights of the enrichment. The developer controls the source files and is most capable of preparing and transferring these. The researcher has most knowledge about the contents and can best provide most metadata. The publisher may want to pose additional restrictions regarding the accessibility of the enrichments. In this case the agreement should be made with the publisher.

The intention of this project is to position the archive as a fallback facility where the data can be accessed only when it can no longer be accessed via Brill. If DANS and Brill want to make agreements on the access-terms, then Brill needs to be the depositor, which requires that the researcher and/or the developer need to transfer the appropriate rights to Brill. Within this project, by exception, DANS can manually change the depositor to the publisher after others have submitted it to DANS. DANS and the publisher can setup a framework contract that arranges details about providing access, determining the official depositor or the costs for preserving the enrichment (DANS doesn’t charge individual researchers for depositing data under 1000MB; Organizations are charged for datasets that cannot be published as open access).

Note that Brill, the researcher and the developer can be registered as either creator or contributor. This allows the enrichment to be found and credits to be rewarded.

\textit{DANS recommends (for the short term) that the developer deposits the enrichment on behalf of Brill and that DANS changes the depositor-role to Brill. The researcher and the developer will be listed as creators and Brill will be listed as contributor. DANS and Brill should discuss the conditions for depositing the dataset and making it available for third parties. DANS should create facilities to support a researcher to deposit ‘on behalf of’ an organisation.}

\textit{Il-2-5: Validation}

Validation involves the final check by an archivist to ensure the quality of the data and metadata. No special validation is required for enrichments.

\textit{Il-2-6: Publication and Access}

Once the deposited enrichment is validated by the archive it will be published. This implies that the archive will make the details available via a splash-page, and that academic portals (such as NARCIS.nl) can index it. Depending on the access-rights agreed by DANS and Brill, the enrichment and/or the source files can be downloaded directly from the archive, or DANS can redirect users to the platform of Brill where the enrichment can be accessed.

\(^5\) Instructions for depositing historical data. \url{http://www.dans.knaw.nl/en/content/instructions-depositing-historical-data}
DANS’ current access licenses are tailored towards the preservation of research data. Such licenses can be incompatible with licenses of e.g. Brill, or with the licenses of other sources that researchers want to combine. DANS acknowledges these restrictions and is currently taking the last hurdles to implement Creative Commons Zero (CC0) licenses for its archive.

*DANS will publish the dataset as ‘other access’ as long as Brill makes it available. DANS and Brill should agree when DANS can make the dataset available as ‘open access’. DANS should continue to align its licenses with that of other data providers.*

**II-2-7: Preservation**

The enrichments are not mere 3D models of historical instruments or processes, but visualizations containing animation and interaction. This makes the enrichments complex and context-dependent, making it difficult to preserve them. How can complexity be reduced? One should carefully consider each feature: Is it essential? Can it be separated? Does it require advanced features?

Taking the astrolabe as an example we can assume that all parts are essential if we follow the Integrated Online Exhibit Model. However, the introduction-part and the exercise-part can potentially be implemented as separate videos and images, leaving only the instrument-part as a challenge. How well this can be preserved depends on the features that are used and how well these are supported by various formats and software packages. Depending on the scientific value of the relevant part (e.g. the amount of interpretation that has taken place?) one should be stricter or less strict when using advanced features.

The separation into different parts does not need to hinder the usability: the visualization can reference the different sub-parts or one could provide the separate components merely as a fall-back in cases when the Unity format s (no longer) supported by a client.

Dealing with such complexity / context-dependency is typical for software preservation. In fact, the model contains C# code to support animation and interaction. The complexity and context-dependency make software preservation very difficult and there are not yet practical solutions to facilitate software preservation. As such, it is not yet a service by DANS. However, DANS acknowledges the importance of software preservation and is currently setting up an alliance with the Netherlands eScience Center⁶ to promote the sustainability of software, similar to the UK Software Sustainability Institute⁷.

*DANS recommends that the enrichments be carefully considered in terms of their added value and the technologies that are used. DANS cannot yet commit itself to preserving software, but will actively support initiatives to promote and increase software sustainability and durability. It will store the programming source when available and where relevant for the data.*

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⁶ Netherlands eScience Center. [http://esciencecenter.nl](http://esciencecenter.nl/

⁷ UK Software Sustainability Institute. [http://www.software.ac.uk](http://www.software.ac.uk/)
Persistent identifiers can be used to create durable citations of a resource. Persistent identifiers are unique identifiers that are connected to the current location using a maintainable registry. This allows the owner (or the one that is responsible) of certain resources to sustain the links to these resources once they move to different locations, so that the researcher are always redirected to the actual location. In the case of an enrichment we assume that the persistent identifiers should first point to a location at Brill and that somewhere in the future it should point to a location at DANS. But in order to allow DANS to administer any location-changes, the ‘ownership’ will also need to change.

Multiple persistent identifier solutions exist. Brill currently uses DOI identifiers from CrossRef, a solution developed by and for publisher. DANS uses URN:NBN identifiers as defined by IETF, a solution by and for durable repositories or archives. DANS will, in addition, support DOI identifiers from DataCite, a solution developed for data citation. Each of these systems allow the ownership of an identifier to be transferred to another organization. It typically implies that either the old ‘owner’ notifies the system of the new owner, or that the new ‘owner’ can show a proof of ownership.

However, this requires that a new owner should then adopt the policy, fees and standards (for registration and or metadata) of this solution. More concrete: DANS should become a CrossRef member and, for example, pay fees based on ‘the number of publications’ that it publishes. On the long-term, such a membership is difficult to sustain for a data archive.

An ideal solution would be when the DOI of the enrichment can be transferred from the CrossRef domain to the DataCite domain. DANS can then administer this DOI using its existing arrangements with DataCite. Such a transfer is not yet a common use case: we could not find documentation and did not get answers from these organisations. We also expect that there will be conflicts in policy and the metadata that should be provided.

DANS recommends Brill to assign DOI’s from CrossRef. DANS will promote the use case of transferring DOI’s from CrossRef registry to DataCite registry. In the meantime we should ensure that the enrichment is discoverable and identifiable via relevant portals and search engines and that DANS and Brill make a written agreement that states when and under what conditions DANS is allowed to take ownership of / responsibility for specific DOI’s.

The project publishes the enrichments on a demo-website that mocks the platform from Brill. The demo creates entry pages for the publication where the enrichments can be published. The enrichment itself is placed on a separate level. This allows it to be referenced separately from the original publication and it prevents the page for the original publication from incompatibility-issues regarding advanced enrichments.

The page for the enrichment starts by showing the enrichment itself, followed its metadata. We recommend that the metadata published by Brill and by DANS are equal. Both the publication-page and the enrichment-page allow for contextualization. This project considers the publication and the enrichment to be explicitly related: the enrichment is a multimedia supplement created for this
publication and as such, the enrichment belongs to this publication. Similarly one could consider placing citations here. Other resources about e.g. astrolabes are considered to be just related and are placed in a separate box. An important limitation here is the scope of the Brill platform: it promotes the availability of Brill publications. Promoting external informative resources on this platform would require a severe change in policy / business model.

Screenshots of a normal and a mobile display for the publication.

The pages contain information for citation of the resource. These include the persistent identifier for the involved resource. In addition, there is a QR code that can be reused in printed sources and that allows mobile devices to access the resource via its persistent identifier.

The QR-feature implies that these pages support display on mobile devices. The pages support so called responsive layout. This allows the layout to automatically fit the screen by rearranging the sections of the page. In this case the metadata and the thumbnail of the publication or the different types of related contents get placed underneath each other instead of next to each other.

Unfortunately the enrichment itself doesn’t support mobile display: there is no or limited availability of plugins that can interpret and display the enrichment and the limited screen-size of mobile devices would limit the design of the enrichment. This issue is related to the preservation issues. Similar to the preservation-solution, the mobile users are offered a fallback to a screencast of the enrichment: the platform will serve a video-screencast if it detects that the client doesn’t support the Unity player.
All enrichments of the dynamic drawings project are published as open access. This allows others to reference the enrichment and reuse it. This is relevant for the self-describing enrichments that are designed from a user perspective. This becomes less relevant when the enrichment is created from a source perspective. In that case, interpretation of the enrichment requires access to the source. Brill could restrict access to licensed users, or, Brill could provide open access and tempt users to acquire the original sources.

DANS cannot advice Brill on access-strategies, business models or mobile strategies. DANS promotes open access to research data and can offer services to publishers if this improves the accessibility of research data. Contextualization can contribute to transparency, discovery and interpretation of the resources. QR technology can help to discover and access online resources that are related to a printed publication. On the short-term, the durable formats can function as a fallback for less-advanced clients.
II-3: Archiving Interactive 3D Visualizations: Conclusion

Implementing dynamic visualizations with a publication poses three major challenges: sharing responsibilities for short- and long-term, publishing them on (mobile) platforms to allow discovery and preserving the complexity of interactive visualizations.

The enrichments can easily become complex and context-dependent which makes preservation difficult. This requires the usage of complexity or advanced features to be carefully considered. Archives can contribute to this by setting guidelines and by exploring and supporting interoperable formats.

How can DANS and Brill arrange the availability of the enrichment together, or, how can responsibility for this availability be split? The original thought is to split this in terms of time: short-term and long-term. This requires clear agreements to define short-term and long-term. Furthermore it is important to acknowledge that a publisher and an archive implement different policies, metadata and service levels. The DOI-services are an example of this. To ensure a seamless transfer, DANS and Brill should strive to align these were possible.

There are technological challenges. Mobile technologies are developing fast, but are still limited in some aspects. QR-technology is not available by default, screens are limited in size and they are strict in allowing plugins to support 3D visualizations. Like for preservation-purposes, this requires careful consideration when using advanced features: are they necessary? What happens if there is no (more) support for this feature?

Perhaps even more important are the challenges on a strategic level. Contextualization and reuse can be promoted by publishing the enrichments as independent, open access and citable resources. Since this could have a severe impact on the publishing strategies of Brill, this requires a consideration from these new enhanced publication formats from a business perspective.
III-1: Introduction

Linked with the Brill content, these enrichments serve as a valuable supplement to current journal articles and books, not only in history of science but in all corners of the humanities & social science spectrum. In a more ‘natural’ situation, i.e. when the visualization is not created as part of a project like this, an author of a manuscript either submits a self-made visualization to be published alongside the book / article, or Brill itself arranges the development of such an enrichment. In both cases, the resulting publication is more valuable and can be priced higher or sell better than a work without dynamic content.

Furthermore, usage of the publication – read: traffic to Brill’s content platform, is stimulated. Once deposited, persistently identified and preserved for future use at a URL, e.g. the archive of DANS or at a service provider like FigShare, content accompanied by a visualization is expected to be used (viewed, downloaded) more often because of higher information value and the fact that external links from DANS or other sites are made.

For practical / technical reasons, Open Access publication of the enrichment under CC-BY license seems most suitable. As (governmental) research financers increasingly pose the condition of open access disclosure for research-related data and conclusions, visualizations should naturally also be freely accessible and ‘discoverable’ as much as possible; for the expert scholar and the layman alike.

Books will become ‘richer’ in content and value to the reader. Even if the visualization is available in OA, such books can be priced higher – to recognize the additional value but also to cover costs of creating and facilitating the enrichment.

III-2: Possible workflows & technical implications:

A publisher offering the possibility of publishing enhanced monograph or edited book volume, will be more attractive for authors. Especially if in research assessment exercises, publications accompanied by visualization were valued higher than publications without.

1. Author submits his own idea for a design or visualization along with manuscript (journal article, book chapter, monograph); resulting in more valuable content.
2. Author requests publisher to create visualization, author pays publisher
3. Publisher develops a toolkit for creating the enrichments.

What publication solutions can Brill offer at present:

- Visualization service, outsourced to Wild Card or other party, at a charge
- Posting of visualization as supplementary material alongside PDF / HTML on Brill Online Books and Journals, without DOI
- Posting of visualization on platform at DANS, per agreement (to be drafted)
- Link (url or QR code) in article / book chapter / book PDF to DANS url (to do) and vice-versa

In the future (desired):

- Posting of visualization as supplementary material alongside PDF / HTML on Brill Online Books and Journals, with DOI and facilitated by the required media player (Unity)
- Posting of visualization as supplementary material alongside PDF / HTML on a service like FigShare (http://figshare.com/about), with DOI.

III-3: Conclusion.

With the outcome of this experiment Brill can ensure the dissemination and preservation of enriched publications. Open Access publication of the enrichment under CC-BY license seems most suitable. Books will become ‘richer’ in content and value to the reader. Even if the visualization is available in OA, such books can be priced higher – to recognize the additional value but also to cover costs of creating and facilitating the enrichment. With the outcome of this experiment Brill can ensure the dissemination and preservation of enriched publications. Moreover, the publisher foresees extra services to authors by providing a toolkit for new enrichments or to create those against cost prize, in case an author is unable to do so.
CONCLUSION

The aim of the Dynamic Drawings in Enhanced Publications was not just to produce creative illustrations, but interactive scholarly multimedia animations that would contribute to a critical interpretation of seventeenth century texts and comments hereof. In total six animations were produced that can be activated by clicking on QR codes next to illustrations in books on/facsimiles of seventeenth century works on astronomy, physics, biology, fortification, land surveying and mechanical engineering. During the making of these animations several historic-methodological issues raised. For instance do you visualize a theory of which you know in hindsight that it is incorrect and how do you contextualize this knowledge without interfering with the original source? (Descartes case). Or, is it allowed to use additional historical source for the making of a visualization if the original source that is used for the virtual reconstruction provides less accurate information? (Ramelli case). Moreover, for the development of storyboards different types of target audiences were individuated that resulted in discussions of how much freedom of manipulation the user would have. Such questions put forward in the development of typologies and creation of storyboards described in part 1, demonstrated that the making of enriched publications indeed can enhance critical interpretations of historical sources and contextual information hereof. Part 2 and 3 described the development of new, comprehended workflows for re-use and business models. These experiments animated discussions about the ownership and responsibility of external links and issues of copy and author rights. An archiving workflow was developed with persistent identifiers to ensure the long-term availability of the enriched publication and the reuse of the 3D visualizations. DANS will archive the enriched publication, its source files and a durable screencast of the visualization. Brill will be the primary publisher for the animated visualizations. Linked with the publisher’s content, these enrichments might serve as a valuable supplement to current journal articles and books, not only in history of science but in all corners of the humanities & social sciences spectrum. As (governmental) research funding organizations increasingly pose the condition of open access disclosure for research-related data and conclusions, the visualizations should naturally also be freely accessible and ‘discoverable’ as much as possible; for scholars and non-experts alike. Open Access publication of the enrichment under CC-BY license turned out to be to most suitable business model for re-use. This pilot project not only revealed how publications enhanced by dynamic visualizations can supplement and clarify original historical descriptions of scientific and technological mechanisms and processes, but also how they can be incorporated in an sustainable way into the traditional (paper) publication ecology using new archiving strategies and alternative business models.
APPENDIX: PUBLICATIONS AND PRESENTATIONS

Publications

Maarten Hoogerwerf, “Bewegend beeld in oude drukken. Onderzoekers en uitgeverij experimenteren met visualisaties.”, E-Data&Research, June 2013, p. 7

Presentations,

Tiemen Cocquyt, “Proeven van Vroeger”, Department Mathematics and Natural Sciences, Leiden, 23 April 2013. Titel was de NLT-module ‘Proeven van Vroeger’.


Demonstrations of visualizations in Brill Publication Booth at the following international conferences:

- 24th International Congress of History of Science, Technology and Medicine, iCHSTM 2013, in Manchester, UK, 21-26 July 2013
- History of Science Society Congress in Boston, MA, USA, 21-24 November 2014