A Practical Research into Preservation Strategies for VR artworks on the basis of Justin Zijlstra's *100 Jaar Vrouwenkiesrecht*

In the collection of Atria Kennisinstituut voor Emancipatie en Vrouwengeschiedenis

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Images 1 and 2 - Screenshot from *100 Jaar Vrouwenkiesrecht* as played on Unity.

Preamble to the text

This publication is the outcome of a case study-based research project into Justin Zijlstra's VR artwork, *100 Jaar Vrouwenkiesrecht* (2018-2019), subsidized by the Dutch Digital Heritage Network and conducted on behalf of Atria Kennisinstituut voor Emancipatie en Vrouwengeschiedenis. The research for and composition of this report was undertaken by Olivia Brum and Mauricio van der Maesen de Sombreff with significant contributions by Eléonore Bernard and Gaby Wijers. For its approach, this project took the results from the recent research conducted by Tate's Time-based Media Conservation Department, *Preserving Virtual Reality Artworks: White Paper* (McConchie and Ensom, 2021), which it used as a basis for the practical examination of the case study. Outcomes included the in-depth documentation of the artwork and its components, isolation of the main preservation concerns, the investigation of a number of conservation strategies and the creation of several disc images of the work for preservation purposes. It also included the formulation of a more general "Recommendation Checklist for the Preservation of VR artworks" to be used as a conservation guideline.

1.   Introduction

Given a subsidy from the Dutch Digital Heritage Network (NDE), Atria Kennisinstituut voor Emancipatie en Vrouwengeschiedenis (Atria) in collaboration with LIMA have been tasked with a number of sub-assignments to investigate the long-term preservation of Justin Zijlstra's *100 Jaar Vrouwenkiesrecht* (2018-2019)[1]. The work, commissioned by Atria in honor of the 100 year anniversary of women's suffrage in the Netherlands and created in collaboration with FieldLab Virtual Worlds, forms an unique opportunity for practical study of the recent research in the *Preserving Virtual Reality Artworks: White Paper* (McConchie and Ensom, 2021). This study, further referred to here as "The White Paper", is part of an ongoing study, framed by Tate's Preserving Immersive Media Project, that explores the challenges faced when preserving artworks that involve virtual reality and other immersive media technologies. The prescribed steps therein have informed the approach and focus of this case study in conversation with LIMA's own research questions which are as follows:

1. How to take a future visitor into this experience and preserve components and experience?
2. What is best practice in preserving and documenting VR artworks?
3. What is best practise in related research in preserving 360 video, real-time 3D, AR and MR? What is the concept and functionality of the (interaction) and technology used? How can the experience and interaction be mapped and the technology preserved? How can the artwork be presented in the future?
4. How do the different versions relate to each other?
5. How can we and others study, experience, and use the different versions? How can we distribute VR works/ what are the minimum requirements/what is best practice?

To begin to answer these questions indepth research has been conducted into the records and documentation received from Atria to try to reconstruct the art historical background of *100 Jaar Vrouwenkiesrecht*. From there this paper has delved into the documentation of the work and its technical details, taking as its guide the important characteristics dictated in "The White Paper." Throughout this process an eye has been kept to the future, as this paper has attempted to isolate what is important to document now to promote the longevity of this comparatively new work. This has also included an emphasis on it's sustainable long-term storage and the testing of migration strategies that address the inevitable obsolescence of it's proprietary components.

The brief project which this paper describes is, as mentioned before, simply a smaller part of LIMA's research into the preservation of VR in collaboration with Atria and NDE. This larger research project is set to culminate in an NDE workshop planned for November 17th, 2021. The current segment of this research concludes with this publication and with a roundtable discussion that was held on July 20th, 2021 (see Appendix A.12). At the discussion representatives from institutions such as the Tate, University of Dundee, House of Electronic Arts Basel (HEK), Atria, NDE, Rhizome, C3 and Zentrum für Kunst und Medien Karlsruhe (ZKM) provided much needed insight into the project at hand. In combination with input from "The White Paper" the findings of this session have informed the substance of this paper.

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[1]   Translated in English as *100 Years of Women's Suffrage.*

2. Artwork Description

This section will provide background information regarding Justin Zijlstra's *100 Jaar Vrouwenkiesrecht* by first providing an in-depth identification of the artwork, its content, hardware specifications, software environment and sculptural components. Followed by the work's art historical background as well as the works production and exhibition history. The combination of this information is hoped to paint an accurate picture of the artwork for understanding of the later sections of this paper. Further, section 3, will elaborate on the findings preliminarily discussed here.

2.1. Artwork Identification

The artwork consists of an "on rails"[2] VR animation that takes the visitor through the streets of Amsterdam during the marches for women's suffrage in the early 1900s. The application runs on an Oculus Quest device which, when installed, is mounted on a sculptural support structure, constructed of wood and metal. The following subsections will provide more information about the specifications of the individual components.

2.1.1. Description of Content[3]

The work begins in a low-ceilinged room, while atmospheric music plays in the background. Near the back wall sits a table and chairs while off to the side a lamp sits on a side table. A cut-out of a woman stands in the foreground, while behind her stands a cut-out of a man. Both figures are outlined in pastel colors. The figure of the man moves to the right (directions depending on which way the user is facing in the VR environment) as a door opens and he goes out leaving only the woman in the room. Over the atmospheric music a female voice begins to speak in Dutch interspersed with English phrases about how a question that she often gets asked is how to find one's voice (see Appendix A.1 for full transcript of audio track). The cut-out of the woman begins to drift around the room as the voice gives some prior tips on finding one's voice, until following the man out the same door.

Image 3 - Screenshot from 360° video displaying opening scene. Source: Atria Kennisinstituut, "Beleef 100 Jaar Vrouwenkiesrecht!" Youtube video, 3.26, 6 January 2020.

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[2] In an "on rails" locomotion the user has no control over their position in the VR environment. The only possible interaction is to look around. Think of this as a VR roller coaster experience where the user rides along on tracks in VR.

[3] A 360° video of the artwork was supplied as a documentation tool by Atria and the artist. From this the following description and screenshots have been compiled.

The perspective begins to drift to the right showing a wall with framed photographs and then the user is pulled up and through a set of high windows. The perspective continues to pan to the right through the successive rooms as if the user is walking. Each room is composed to resemble a certain purpose and objects are included to illustrate traditional roles expected of women. These include a living room with a cradle, an office space with desks, and a sitting room. Inside every room female figures stand as the camera pans by, moving first right, then forwards, and lastly right again. In this part of the animation the narrator discusses teaching the user her routine for finding her voice. She says to do this, "we are going to sing a battle song." The song by English suffragette Ethel Mary Smyth begins as a hum and then the narrator says, "Let's add some words." A choir begins to sing in earnest as the user is pulled out onto the street where women are marching (at 1 minute and 48 seconds into the animation).

Image 4 and 5 - Screenshots from 360° video showing a selection of the interiors included in the work. Source: Atria Kennisinstituut, "Beleef 100 Jaar Vrouwenkiesrecht!" Youtube video, 3.26, 6 January 2020.

Image 6 and 7 - Screenshots from 360° video showing a selection of the interiors included in the work. Source: Atria Kennisinstituut, "Beleef 100 Jaar Vrouwenkiesrecht!" Youtube video, 3.26, 6 January 2020.

The user is pulled along as if they are part of the demonstration. In this part of the animation the two-dimensionality of the characters are readily made apparent as if the user looks behind them he sees the figures head on but if they look in front of them they see a series of multi-colored shapes representing the backs of the figures. From the sky pamphlets are falling as around the parade of figures stand the outlines of a scattering of buildings. The user is then pulled to the front of the procession as it goes over a bridge and into a square at which point buildings rise up out of the ground to be covered with different banners from the Dutch women's suffrage movement and a crowd surges to the center of the square. As the singing intensifies another building rises from the ground replacing the prior one filled with other female figures. During this part the narrator speaks over the singing encouraging the user to use their voice and concluding with how although it takes

more than the time allotted how important it is to do. The animation then ends with a dark screen and the artist logo at 3 minutes and 27 seconds.

Image 8 and 9 - Screenshots from 360° video giving a visual impression of the characteristics of the marching segment of the work. Source: Atria Kennisinstituut, "Beleef 100 Jaar Vrouwenkiesrecht!" Youtube video, 3.26, 6 January 2020.

Image 10 - Screenshot from 360° video displaying closing scene. Source: Atria Kennisinstituut, "Beleef 100 Jaar Vrouwenkiesrecht!" Youtube video, 3.26, 6 January 2020.

2.1.2. Hardware Specifications

For the purpose of this research one of the two 64GB Oculus Quest headsets, acquired by Atria on September 19th, 2019, was given on loan for the duration and has informed this section as well as Section 3.3.1 concerning the user experience of the hardware. According to "The White Paper" VR hardware systems are made up of interdependent hardware components often used by artists in consumer-oriented packages (McConchie and Ensom, 5). This was also the case here where the work makes use of an Oculus Quest head-mounted display and two second generation Oculus Touch controllers that would have been supplied together. The Oculus Quest released in May of 2019 was discontinued in September 2020, to be quickly succeeded by the Oculus Quest 2 in October 2020,

highlighting the first of many preservation difficulties with proprietary hardware that will be investigated further in Section 4.2 Conservation Strategies.

For specifications it makes use of integrated stereo speakers used here for the audio and four built-in sensor cameras that permit positional tracking, relaying specific information regarding the position of the user's head as well as the controllers. In fact for all functions the Oculus Quest serves as a stand-alone device, using an Android-based operating system built into the headset itself. For display it uses OLED, a refresh rate of 72 Hz, a resolution of 1600 x 1440 pixels per eye and a horizontal Field of View of 94° (+/- 5.1) (see Table 1 for further specifications).

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Brand:             Oculus
Model:              Quest
Display type:        OLED
Refresh rate:        72Hz
Resolution:        1600 x 1440 pixels per eye
Processor:            Qualcomm Snapdragon 835
Graphics:            Qualcomm Adreno 540 GPU
Memory:            4GB RAM
Internal storage:   64GB
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Table 1 - Technical details for Oculus headset

2.1.3. Software Environment and Digital Assets

The application was created in Unity [https://unity.com/], a popular game engine available on most computer platforms that has both free and paid licensing options. The free license is for personal use or for use by companies generating less than $100,000 annually. This extremely affordable price tag and the low know-how threshold required to work with proprietary software often makes it an artist's first choice, a topic raised during the VR roundtable. Further the application code written in C++ in Unity controls every aspect of the virtual environment, from the camera movements to the animation of the crowd and the city facades.

Software environments are built up around the VR application itself that's executions engage the other layers. Layers introduced by third-parties, like Unity, can introduce variance which is important to isolate to understand the software environment of a given work (Ensom and McConchie, 9). In this case the Unity Editor will run on any CPU with X64 architecture with an SSE2 instruction set support. Further, it is fully supported by Windows and MacOS, with partial support for Linux operating systems. To correctly build the application package, the correct version of the Unity Editor (2019.3.14f1) is required, plus the additional installation of the Android apk and OpenJDK addons. On the Oculus Quest headset loaned from Atria the firmware and runtime versions were noted as follows 10.1.0.144.427.179270078 and 10.1.0.144.427.179270103, respectively. Further it runs on a 64-bit CPU with ARM architecture (Snapdragon 835). No added special hardware such as GPU accelerators is required in the development of the environment.

Unity's animation system is based on the concept of Animation Clips, which contain information about how certain objects should change their position, rotation, or other properties over time. This type of animation is made directly through the Editor's GUI, without the need of code scripting. Animation Clips are organised into a structured flowchart-like system called "Animator Controller". The Animator Controller keeps track of which clip should currently be playing, and when the animations should change or blend together.

Based on the provided code, each reproduction of the artwork is unique, as some aspects of the script rely on random generation. The crowd walking in the streets is a good example. The speed as well as the starting position of each character begins from a random number (confined within a convenient range). This characteristic makes the original artwork slightly different from the 360° video exported to YouTube, since no aspect of the exported video will ever change.
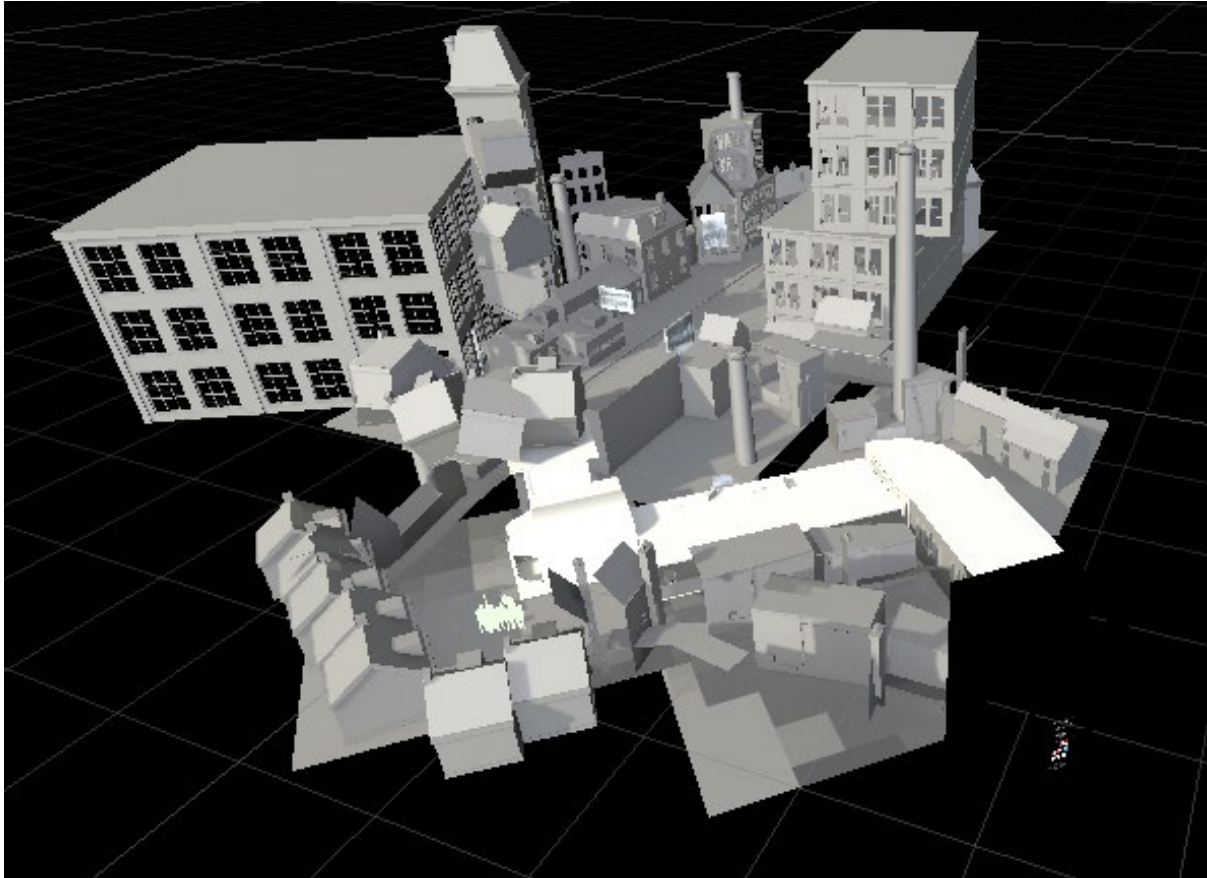

Image 11 - 3D model of city as representation for Amsterdam. Source: Unity Project Assets

The project assets included in the Unity project contain everything required to generate the artwork including game scenes, animation timelines, audio files, C# scripts, graphics shader code, materials and 3D models, which can be found within this folder (Unity Project folder → Assets).
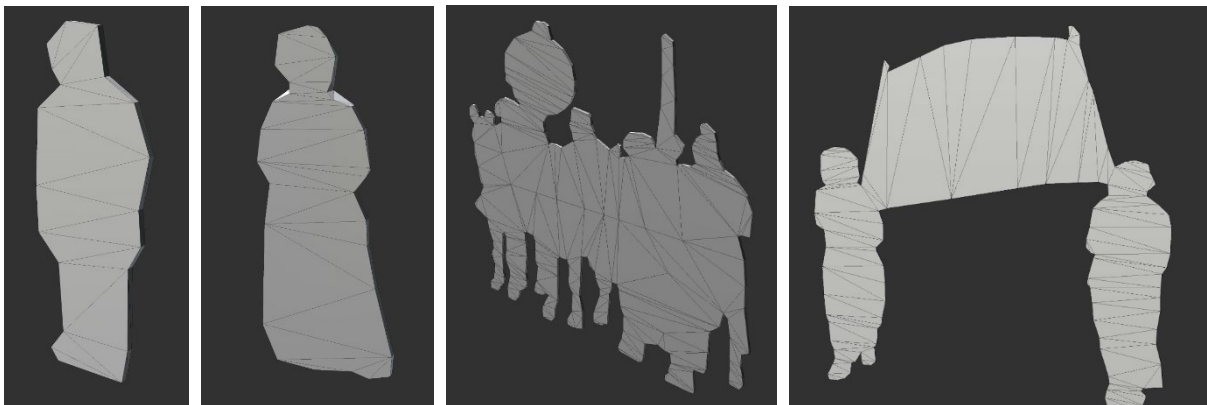
Images 12, 13, 14 and 15 - Selection of models from the Unity Project / Assets / FBX folder. Source: Unity Project Assets

2.1.4. Sculptural Component

A sculptural element has been constructed by the artist to mimic a "tower viewer" and give the semblance of zooming in on a moment in history when the work is installed (see section 2.4 for image). In the Field Lab Collaboration agreement the "tower viewer" is proposed as a method to secure the work against theft when exhibited in public spaces as well as, by resembling a familiar object, present an understood method of engagement, creating a point of access for visitors unused to VR (see Image 16). It was also intended to provide support for visitors suffering from motion sickness, making it the preferred method of installation for this exhibition. It should be noted that this installation form severely restricts the ability to rotate perspective within the VR environment. Further it was not possible to document this component of the work thoroughly as it was not available during the timeframe of this project. Thus, the photographs of the work's construction provided by Justin Zijlstra have been analyzed and summarily described here. From these photographs the time frame within which the "tower viewer" construction was created has been dated from September 4th, 2019 to September 19th, 2019.

Image 16 - Figure demonstrating artistic idea for sculptural elements of the work from 2019 Presentation by Justin Zijlstra. Source: Courtesy of Atria and Justin Zijlstra

The sculptural elements are constructed of a long wooden stand with a hole drilled through allowing wires to pass to the top third of the wooden pole where another hole permits them to exit (see Image 17). A smaller square wooden piece has been attached to the top of the wooden pole to secure the red painted metal elements (assumed to be metal and referred to here as such but could be plastic). The metal elements are secured with a narrow strip of metal at the bottom by two points from which two narrow prongs stretch in a V-shape. In the middle a red oval piece of metal is attached touching at the v-shaped structure at 4 points (see Image 18).

Image 17 and 18 - "Tower viewer" during construction by artist and when finished, respectively. Source: Courtesy of Atria and Justin Zijlstra

2.2. Art Historical Background

The specificity of the goal for which the artwork was commissioned by Atria is a product of the organization's ongoing mission to ensure gender equality as well as collect, manage and promote women's heritage. A historic moment of great importance to women's history and well represented in Atria's archive was the achievement of women's right to vote in the Netherlands, the 100 year anniversary of which was to be in 2019. To celebrate this Atria commissioned a work that, as Tjarda de Haan, former head of collections at Atria, explained at the roundtable, would allow visitors to experience the demonstrations as if they were really there. To do this the artist, Justin Zijlstra, drew on Atria's extensive collection of photographic material, formerly the property of the International Archief voor de Vrouwenbeweging (IAV).[4] As has been seen already in Section 2.1.1, cut outs of these photographs have been used to populate the VR environment and tell the virtual story of the fight for women's suffrage in the Netherlands.

2.3. Production History and Collaborations

The development of the commissioned VR artwork could only be realized after Atria, in collaboration with partners Amsterdam Public Library Foundation (OBA), private partner Justin Zijlstra and Knowledge Institution: University of Utrecht, Prof. Dr AH Pieters, History, digital research methods

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[4] The 'Internationaal Archief voor de Vrouwenbeweging' (IAV) (English: International Archives for the Women's Movement) was founded in Amsterdam in 1935, as a repository to collect and preserve the cultural heritage of women and make the documents of the movement available for study.
In 2013, the institution which houses the collection was renamed as 'Atria, Kennisinstituut voor Emancipatie en Vrouwengeschiedenis' (English: Atria, institute on gender equality and women's history). The Collection still carries the name 'IIAV'. (source partly: https://en.wikipedia.org/wiki/International_Archives_for_the_Women%27s_Movement)

and reuse of heritage won a pitch with a sum of money from Fieldlab Virtual Worlds, part of CLICKNL, Top Consortium for the Creative Industry. With the funding and input from these parties the VR experience, *100 Jaar Vrouwenkiesrecht,* was designed by the artist Justin Zijlstra and presented in a series of exhibitions, see Section 2.4.

Further subsidy was provided later by the Digital Heritage Network (NDE) for a series of sub-assignments that would address the long-term preservation of the work after exhibition, and of which this research composes a part of. These three sub-assignments are as follows:

A. Atria investigates where preservation/digitally sustainable storage of the complex data can best be accommodated. This research has resulted in LIMA being chosen as the best location. A contract has been concluded between the two parties for storage for the next 5 years included with the documentation of the data. LIMA's loan agreement for the VR goggles has been extended for the duration of the study.
B. The VR experience has been transferred to a 360° degree video available on YouTube with English subtitles for dissemination purposes.
C. A description of the challenges posed by sustainable storage of complex data based on this case-study is to be shared in the context of an NDE workshop of which an interview with the artist, Justin Zijlstra, will be part of this.

Sub-assignments A and B have been completed, sub-assignment C will be carried out by LIMA in 2021.

2.4. Exhibition History

The exhibition for which, *100 Jaar Vrouwenkiesrecht,* was commissioned and presented was, "De straat op! 100 jaar vrouwenkiesrecht en activisme"[5] (September 28th, 2019 - January 12th, 2020) produced in collaboration with the Openbare Bibliotheek Amsterdam (OBA) and presented at the OBA Oosterdok in Amsterdam.[6] The work was further presented in three different exhibition spaces: first as a solo presentation at Atria (27.9.2019 - 5.1.2020), and then later in a more abbreviated form as part of the Pop-Up Expo which took place at the OBA Javaplein (17.2.2020 - 1.3.2020) and in the OBA Hallen (4.3.2020 - 27.4.2020) (see Figure 20 - 21). For this the VR artwork traveled with the exhibition (Atria Kennisinstituut voor Emancipatie en Vrouwengeschiedenis 2020).

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[5] Translated in English as "To the streets! 100 years of women's suffrage and activism."
[6] Translated in English to Amsterdam Public Library

Image 19 and 20 - Documentation of the artwork installed without the "tower viewer"[7] at the symposium "In strijd met de roeping der vrouw!"[8] presented on October 17th, 2019 at the Koninklijke Bibliotheek of the work without the "tower viewer" as it was presented at the OBA Javaplein, respectively.[9] Source: Courtesy of Atria and Justin Zijlstra

[7] At this time the "tower viewer" was being used in the exhibition "De straat op! 100 jaar vrouwenkiesrecht en activisme" and as such could not be taken to the Hague for this presentation.

[8] Translated in English as, "Contrary to the Vocation of Women!"

[9] In photo (left): Ellen Boonstra, retired, secretary of the Gender History Association (Dutch: de Vereniging voor Gendergeschiedenis); and in photo right: Sybilla Dekker (left), minister van staat (English: Minister of State) in the Openbare Bibliotheek Amsterdam. (Source: https://www.kb.nl/nieuws/2019/in-strijd-met-de-roeping-der-vrouw and https://twitter.com/latjarda/status/1185111199781998592)

3. Documentation

Near the close of the roundtable Eléonore Bernard, freelance media conservator and fellow author, reiterated the importance of documentation in a conversation concerning how the advance of technology could one day open greater possibilities for recreating obsolete hardware. She questions how the working properties of such a recreation can be compared if a functioning device is no longer available and without having fully documented the user experience. Thus bringing home how essential documentation is as a forward thinking conservation strategy and reiterating the importance of devoting the appropriate time to it in the breadth of this paper. Therefore the following section will address not only the documentation received from Atria with the artwork but also provide an overview of the versions, the user experience of the hardware and software as well as the documentation of the digital delivery and past presentations.

3.1. Available Documentation

File server content at LIMA composed of prior documentation of the work was provided by Atria to LIMA in the form of six We-transfers sent by Desiree Vreke, then Archivist at Atria. These included information concerning the making process of the work submitted by the artist consisting of but not limited to source material, models, sketches, screen captures of drafts in the Unity project and documentation of the construction of the "tower viewer." Other material included in the We-transfers showed documentation of past presentations of the work, interviews with the artist and power point presentations about the work. The following provides a more extensive list:

Digital files provided to Atria by Justin Zijlstra
- A video interview from the artist about the creative process behind the work
  A question and answer document summarized from an interview with Justin Zijlstra and Pablo Uceda Gomez on October 29th, 2019 concerning the work and the contribution of VR to cultural heritage (see Appendix A.2)
  A transcript of the audio track (see Appendix A.1)
- A folder with archival documents used by the artist as source material and inspiration for the project provided by Atria who received it from the artist

Documentation provided by Atria
- The artwork documentation tool, filled out by Desiree Vreke
- Field Lab Collaboration Agreement signed by Justin Zijlstra (artist), Tjarda de Haan (then Head of Collections at Atria), Prof. Dr. Antal van den Bosch (Meertens Instituut Director), and Prof. Dr. Toine Pieters (Professor in digital research methods and reuse of heritage, University of Utrecht) including information concerning payment, distribution of resources, and a detailed project proposal
- Photographs documenting the different exhibitions

3.2. Overview of Versions

There are two main versions of *100 Jaar Vrouwenkiesrecht*: the VR artwork (described prior), and the 360° video. One other version described in the documentation is mentioned in the Field Lab Collaboration Agreement and LIMA's artwork documentation tool described as a free downloadable

app available to visitors of the exhibition. Although not further investigated here, Desiree Vreke describes it in the artwork documentation tool as follows, "In this, the experience is more limited, but by offering it on a mobile platform, it can be more easily distributed outside of the exhibition, as well as being a nice reminder of the experience and the themes of the exhibition. In a compact version, everyone can experience the essence of the exhibition and thus feel moved to visit the real exhibition and installation."

Of the two main versions of the artwork the 360° video, is an export of the application, which is currently available on Youtube and the content of which has been described here in Section 2.1.1 (see further: https://youtu.be/FcisdqZuuSE). It allows more limited interaction and immersion than the VR artwork and is effectively a frozen copy of the work. Regardless of this due to the limited interaction permitted with the VR artwork the 360° video illustrates the characteristics of the work fairly well providing a point of access that does not require an Oculus Quest headset. It was created for documentation and awareness purposes and could potentially be used for the distribution of the work or as an asset for a new VR application to be played in loop (see Section 5.1). In the last form, this would not provide the unique random nuances of the actual application, but given these are unapparent without minute examination, it would provide further access to a similar version of the user experience as the VR artwork.

The last, but primary version, is the VR artwork as it was intended to be displayed and how it has been described prior in this paper. This version, in combination with the Oculus Quest headset and the "tower viewer," was intended for exhibition. It provides greater immersion than the 360° video and gives the artist intended user experience, the documentation of which will be detailed in the following sections.

3.3. User Experience

The user experience of the hardware and the application included here have been compiled based on the experiences of the three authors with the artwork. Therefore, the following text hopes to provide some understanding of the working characteristics of the artwork to be used in the future but could use further elaboration and input from other perspectives to create a more comprehensive picture.

3.3.1. Hardware

When the goggles were examined as part of the project, they were still in their original packaging. On the side there was a small label (LIMA location number) which read "Atria.0001". There were three parts in the box: the goggles and the two controllers (labelled as "L" and "R" for left and right hand). The material of the goggles was rather soft, even though parts of the goggles present a weaved surface. There was a warning to read all the instructions in order to reduce the risk of injury, personal harm and discomfort.

The ON button is located on the right side of the headset, while there is a USB-C input on the left. On the bottom right side of the headset there is a control for the volume, which can be adjusted through pressing on either side of the button. Situated on the bottom left, there is a switch button, which can be used to adjust the width between the two lenses inside the headset. There is an adjustable head strap or harness to support the hold of the goggles onto the user's head and to ensure the correct placement of the goggles in front of the eyes of the user.

On the inside of the harness the following information has been printed regarding the technical details of the headset:

```
VR HEADSET
MODEL: MH-B  MADE IN CHINA
FCC ID:2AGOZ-F8MZ  IC: 20849-F8MZ
5 V --- 3 A
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Table 2-Technical details from inside of Oculus Quest headset harness

The headset holds rather well once it is on the head of the user. The main weight distribution seems to be on the bottom side of the goggles, touching the upper cheek area. This harness uses velcro as a fixating system to adjust it to the desired size. It is possible to wear the headset with glasses, however, it is not particularly comfortable to put on.

Once turned on, the headset emits a loud beep noise and the user sees the Oculus symbol (a zero shape turned on its side). Then, a low-pitched atmospheric background music starts playing and the user can see their outside (real) surroundings, through a grey and somewhat blurry filter. If the goggles are not placed exactly in front of the user's eyes, then the quality and sharpness of the image decreases significantly.

The controllers are linked to the visual in the headset through the presence of a big circle with their respective letter, which allows the user to easily find the controllers without having to take off the goggles. As soon as the user picks up one of the controllers, a white laser beam appears inside of the visual, to mark where the controller is pointed towards. The white dot at the end of the light beam moves in sync with the physical controller in the hand of the user. The controller can be used to select things inside of the virtual reality. Note: if the controller does not seem to work, check the batteries.

3.3.2. Launching the Application

Information on the play area setup and guardian boundary can be found in [Appendix 3](#) and [4](#). Once the guardian boundaries are properly set up, it is possible to enter the menu of the Oculus device. The menu is displayed inside of a virtual room. The room seems to be a circular living room space, with some chairs, a fireplace, a library and big windows with a view of a mountainous landscape. There is a welcome screen, which greets the user with the phrase "Welcome, Atria," below a bar at the bottom of the screen allows the user to switch between different tabs. These options include: Navigate, Social, Sharing, Notifications, and Settings. The default tab is the Navigate page, which has sub-categories such as: Home, Browser, Library, Gallery, and Search.

When choosing the Library tab, the user is then given the following options: Apps, Updates, Unknown Sources, Not Installed, Demos, Tutorials, and Saved. If the user navigates to the Unknown Sources folder, the user will find a subfolder called "100JVK", with the subtitle "com.JustinZijlstra.MSB_100JVK". When clicked, it automatically launches the application.

3.3.3. Application

For a few seconds, the artist's logo can be seen on a black screen, before it fades back to black. After that the user immediately finds themselves in a historic VR room. There is a big white rectangle floating in front of the user with a big black play sign and the information "TURN TO PLAY". The same floating sign can also be seen floating in the right side of the vision field. A floating red ring marks the head movement of the user. As soon as the user turns their head, the floating signs all disappear and the script begins to play.

During the runtime of the animation, the user can look around themselves, however, they cannot interact with the content of the virtual world. In the beginning scene, described in Section 2.1.1, if the user looks around, they can see four times the same room disposition surrounding them. Yet, as soon as the camera starts moving through the different rooms every angle of vision looks different.

At the end of the script runtime, the image fades to black and the ending credits play. Once the credits are finished, the application automatically reloads to the introduction scene, where the user needs to turn their head to start the storytelling. In fact, once the work is launched it will continue to return to the starting point after each play through where it will hold until the next user launches the application by panning their head to the side. The controllers are only needed to set up the application after which this is the only action necessary to start the work anew.

3.4. Documentation of the digital delivery

All together, the artist submitted a large amount of digital data to Atria, which was later entrusted to the care of LIMA for long-term archiving. This digital delivery includes the application itself, including a high number of system files and digital assets, as well as folders with documentation records. A total of 68 552 files was submitted for archiving. Using the open-source application Archifiltre (version 3.2.1) an export of all the files provided by the artist was done, documenting the file paths, file size, creation and modification date. This export was saved as a CSV file [Atria - de Straat op-search.csv] and archived in a Google Drive account owned by Lima with the rest of the documentation surrounding this artwork (See Image 21). LIMA's internal tool "WatsNext" is used to organize all metadata concerning the artwork and related files. This documentation will be available in one of LIMA's file servers (called Videoserver), as to be independent from third party vendors, utilizing the following workflow.

LIMA preserves complex digital offline content by storing all the disk images, digital assets, source code and documentation provided by artists or institutions in the FileServer (Masterfiles). Checksums are added to the files while packaged using the open source .tar format in preparation to be stored on two sets of LTO tapes for long term preservation. Any further descriptive metadata of the files are stored separately from the LTO tape in a database, as part of LIMA's standard pipeline. The files on the LTO are monitored.

1	Name	Type	Size	Last modification	Path
794	IAV_100015055.jpg	jpeg	165.3 kB	03.06.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/P
795	IAV_100017038.jpg	jpeg	190.6 kB	03.06.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/P
796	Capture.JPG	jpeg	197.2 kB	21.10.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat
797	onderzoek	folder	896.5 kB	15.07.21	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/P
798	portretlinks.docx	vnd.openxml	14.7 kB	05.06.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/P
799	Capture2.JPG	jpeg	239.5 kB	21.10.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat
800	Capture3.JPG	jpeg	254.1 kB	21.10.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat
801	14565-414x248.jpg	jpeg	18.7 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
802	Vaandel	folder	663.1 kB	15.07.21	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
803	79033_1.jpg	jpeg	65.3 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
804	Capture4.JPG	jpeg	205.7 kB	21.10.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat
805	NCRD01_104801425_X.jpg	jpeg	87.9 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
806	Vaandel.jpg	jpeg	62.2 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
807	Vereeniging-voor-Vrouwenkiesrecht-Voor	jpeg	40.3 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
808	data.620xC2238x1257+0+101.620x349.jpg	jpeg	79.2 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
809	images.jpg	jpeg	6.5 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
810	dftgfg.jpg	jpeg	22.7 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
811	kieswet.jpg	jpeg	25.6 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
812	sdtfgf.jpg	jpeg	5.4 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
813	stemrecht_voor_vrouwen_in_nederland.j	jpeg	10.5 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
814	vaandel-vereeniging-vrouwenkiesrecht-af	jpeg	22.3 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
815	vrouwenkiesrecht_ANP-1100x400.jpg	jpeg	169.6 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
816	wwwopac-30672326.jpg(mediaclass-arti	jpeg	47 kB	04.12.18	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Bronnen gebruikt in de creatie/Foto's/V
817	100JVK - 1Huiskamer - ziekenhuis.mp4	mp4	28.6 MB	22.10.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat
818	Video	folder	802.5 MB	15.07.21	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat
819	100JVK - CutoutHinge - Android - Unity 20	mp4	16.1 MB	21.10.19	/Atria - de Straat op/JustinZijlstraAtria100JVK-Creatieproces/Presentaties/AdamNetProcesPresentat

Image 21- Fragment from the file "Atria - de Straat op-search.csv"

3.5. Documentation of the Installation

When installed the Oculus Quest is powered through a USB-C connector (5V) and fixed at both sides to the two red prongs that make up the top-most part of the "tower viewer." Before being able to launch the application the Oculus Quest requires the setup of a Guardian perimeter to protect the user from unintended collisions with surrounding objects. Since the Oculus Quest headset is attached to a fixed support structure, a stationary device is sufficient in this case. Yet, the documentation provided with the artwork suggests the setup of a wider boundary for the play area (see Appendix A.4). Further, the application has not been installed directly through the official app store, but compiled from Unity using Android apk tools then copied to the Oculus Quest via the USB connection. Due to this as described before the application can only be found under Library/Unknown Sources/100JVK.

To understand how the work was installed beyond this preliminary information it is recommended that an iteration report be filled out for each presentation of the work, the Guggenheim's provides an example (Guggenheim Conservation Department, n.d.). This should be done in conversation with the artist and include the public reception of each iteration. According to the documentation passed on by Atria to this point there have been three different presentations of Justin Zijlstra's *100 Jaar Vrouwenkiesrecht* each of which should receive a report with input from those who installed the work and were present at the exhibition. In doing so an understanding can begin to be built concerning what is or is not a successful installation of the artwork and questions like if the "tower viewer" is a mandatory component can be answered. In the future, it is of extreme importance to continue documenting the presentation choices being made and any potential technical changes required to show the artwork.

4. Conservation

This section has tried to address the main preservation concerns for the artwork" and determine what conservation strategies can be implemented to combat them. The conservation strategies considered, many of which were also discussed at the roundtable, have looked at how to conserve the hardware/software, create a full hardware back-up, migrate to open format as well as store and monitor the work. On this last point the community standards have been compared against LIMA's own workflow for storage and maintenance of digital-born art. Finally, the last sub-section included here will describe the measures that were already applied and tested as part of this research including disk imaging as well as a series of migration strategies.

4.1. Preservation Concerns

Frequency of failure, rate of change, and dependency on manufacturer specific software are listed as the main concerns for preservation, according to Tate's White Paper (Ensom and McConchie, 33-34). Although failure of the device was not seen in the three exhibitions in which it was presented this forms an especially large preservation risk for this work due to the nature of the presentation spaces. While museums and galleries have set rules of how to engage with works of art that are enforced by personnel, public spaces are unregulated, making art presented in them more susceptible to damage. Higher levels of foot traffic impact the frequency of failure due to larger degrees of interaction. Always having an extra copy available at the exhibition site can mitigate these risks.

In terms of the next concern, the rate of change in the field of VR is a continuing challenge as technology continues to evolve. Further, the artist's decisions are seldom based on maturity of media or supporting hardware/software but rather on what is cutting-edge technology at the time. These choices can also be informed by market availability, cost and desired features of the device. Yet, due to the aforementioned rapid advance of technology, commercially available VR hardware continues to have a short period of sale before being discontinued, as the Oculus Quest was in September 2020. When a device is discontinued, availability quickly decreases creating a steady decline into obsolescence.

The last concern, dependency on manufacturer specific software, holds true in this case. Here the code relies on specific plugins and libraries, allowing the application to run on the Oculus Quest device. As a result, playing the artwork on any other device would require modifications of the Unity engine which for the Unity project in of itself requires a specific version of the editor (2019.3.14.f1). This dependency on proprietary software can also expose the work to further risks in the form of automatic software updates, often integrated into commercial VR systems (Ensom and McConchie, 10). Please refer to the Recommendations Section on how to mitigate these risks. This topic was also touched upon during the roundtable by Dragan Espenschied, Preservation Director at Rhizome, when he mentioned instances where unknowing parties accidentally connected a headset to the computer causing it to automatically update and consequently destroying an artwork.

4.2. Conservation Strategies

Conservation strategies were investigated as part of the roundtable, including topics such as migration to open format, upgrading to long term support, origination of multiple formats for

preservation, creating a disc image and documenting the work by ways of a 360° video to name a few. Documentation as a conservation strategy has already been covered in Section 3 thus it will not be revisited here, but it is an important prior step that, missing severely limits what strategies will be possible to conserve the work in the future. The strategies that have been investigated in this section include conservation of software and hardware; storage and monitoring of the digital archive; creating a full hardware back-up and hardware migration; migrating to an open format and upgrading to long term support.

4.2.1. Conservation of Software

In order to preserve the compatibility of the original software build with the headset it is important to disable all network access to the VR headset, therefore preventing any unintended automatic firmware updates. On the Oculus Quest headset on loan to LIMA this has already been done so it was not necessary to execute this but to instead document the current technical information to verify against any potential changes. These are as follows:

> Version 10.1.0.144.427.179270078
> Runtime Version 10.1.0.144.427.179270103
> OS Version user-396520.6170.115
> Storage 51.30 GB

Further preservation considerations regarding software components are presented in terms of accessibility where migration of the artwork to newer devices and operating systems requires the artwork code to be constantly updated and patched, which can become a resource intensive task. Not only this but this strategy has relatively short-term value when faced with rapid technological advancement and exchange of hardware. Considering this the "White Paper" tentatively suggests an approach they term "incremental migration" whereby VR projects are migrated between engine versions, but they admit without other examples of this it is impossible to verify its viability (Ensom and McConchie, 38).

4.2.2. Conservation of Hardware

Stockpiling has a large precedent in the field of time-based media conservation and is oftentimes a recommended approach for maintaining access to appropriate hardware for works vulnerable to obsolescence. The "White Paper" acknowledges that given the cost of headsets, the short lifespan of this heavily used piece of hardware, and the limited release of such proprietary components this may not be the most effective response for sustaining long-term access, but in the absence of other solutions is the only sensible short-term one (Ensom and McConchie, 34). In stockpiling VR headsets it is important to keep in mind that the firmware version needs to be compatible with the presented artwork. The "White Paper" also recommends obtaining two complete hardware sets, of which, for this case-study Atria is already in possession of (Ensom and McConchie, 34). Further they should be stored in appropriate environmental conditions i.e. lower humidity and temperatures to prevent the corrosion of sensitive internal electronics. As mentioned prior, currently LIMA has on loan for the duration of the project one of the two Oculus Quest headsets acquired by Atria. LIMA's storage facilities maintain appropriate temperature and relative humidity control to ensure the preservation of different types of media art, including the storage of small hardware items such as VR headsets.

4.2.3. Storage and Monitoring of Digital Archive

Next to hardware stockpiling, it is crucial to keep backups of the original software application. In addition to the Android application package (apk), it is essential to archive the original Unity project with the source code and digital assets, as well as all used plugins and libraries. Furthermore, it is

advisable to keep an archived version of the original engine. All versions of Unity - from the current releases back to the Unity 3.x versions - are available for download in the Unity archive [https://unity3d.com/get-unity/download/archive].

When it comes to long-term data storage, keeping multiple copies in different physical locations is recommended. Both SSD disks and LTO tapes are good options for the type and size of data required for this particular project. The digital files provided by the artist have already been archived in the server structure of LIMA, according to standard practice.

Following which they will be further processed in order to ensure future access to the code and assets, using the workflow currently executed at LIMA for born-digital art. To address a Level 1 of digital preservation as stated by the National Digital Stewardship Alliance (NDSL) guideline, several copies of the data are made and stored in multiple locations (NDSA 2019). A copy of all the provided data is first stored on the file server (as has already been done), where uncompressed versions of each first level directory are made using the open source ".tar" format. MD5 checksum hashes of each file are stored as metadata on a MySQL database to allow periodic validation of data and detection of bit corruption. The data is then copied onto 2 sets of LTO tapes for long time archival storage. Every year, the store data is validated against the MD5 file checksums, and rewritten to ensure the longevity of the archive. Since preservation is at LIMA's core, a sustainability plan for future access is available. These preservation strategies are revised every 5 years based on conversation within the community.

It is also possible to automatically generate some basic metadata of all audio, images and video assets for VR artworks, as well as a simplified description of some file types such as 3D models, and code scripts. As an alternative, files could be manually tagged in a database, or attributes could be included in an XFS (extended file system) to further describe the contents of each individual asset.

4.2.4. Creating a Full Hardware Backup and Hardware Migration

Considering the potential for fatal hardware failure and the challenges in migrating the application package to newer devices - should those not support the same version of the engine - it is advisable to have a full backup of the artwork on an identical device (or one of the same type). This is especially important in the context of an exhibition of the work, where the longer runtime during the exhibition could lead to wear and tear of hardware elements.

Right now the subsequent Oculus Quest model, the Oculus Quest 2, is still occupying a leading position in the VR market and is surrounded by a variety of open standards, from its Android open-source operating system, to the support of OpenXR as an abstraction layer. The existence of well documented libraries and plugins for popular developer tools, such as Unity, Unreal Engine and others, encourages the adoption of these devices to a worldwide community of developers.

Obtaining at least two or more Oculus Quest 2 devices and installing the current build apk file into them would be a simple and viable solution to have a working backup of the artwork. As has already been stated, it is essential to disable the network access of these devices and make sure that the automatic updates are turned off. Due to the inevitable obsolescence of electronic components, this strategy is insufficient for long-term preservation, however, it presents a good mid-term solution, especially in scenarios where the work has to be frequently exhibited.

4.2.5. Migration to Open Format and Upgrading to Long Term Support

To minimize the risk of rapid obsolescence, an established and widely available technology is preferable, as is the selection of media technologies based on open standards. Migrating the code to an open standard is considered to be the best way for extending the life of the artwork. This strategy allows the application to be deployed to any platform supporting the standard (Ensom and McConchie, 37). OpenXR is currently supported by the leading VR companies and by the game development community, making it a preferable option compared with maintaining dependencies on a single vendor that might at any point end production or support for a specific platform.
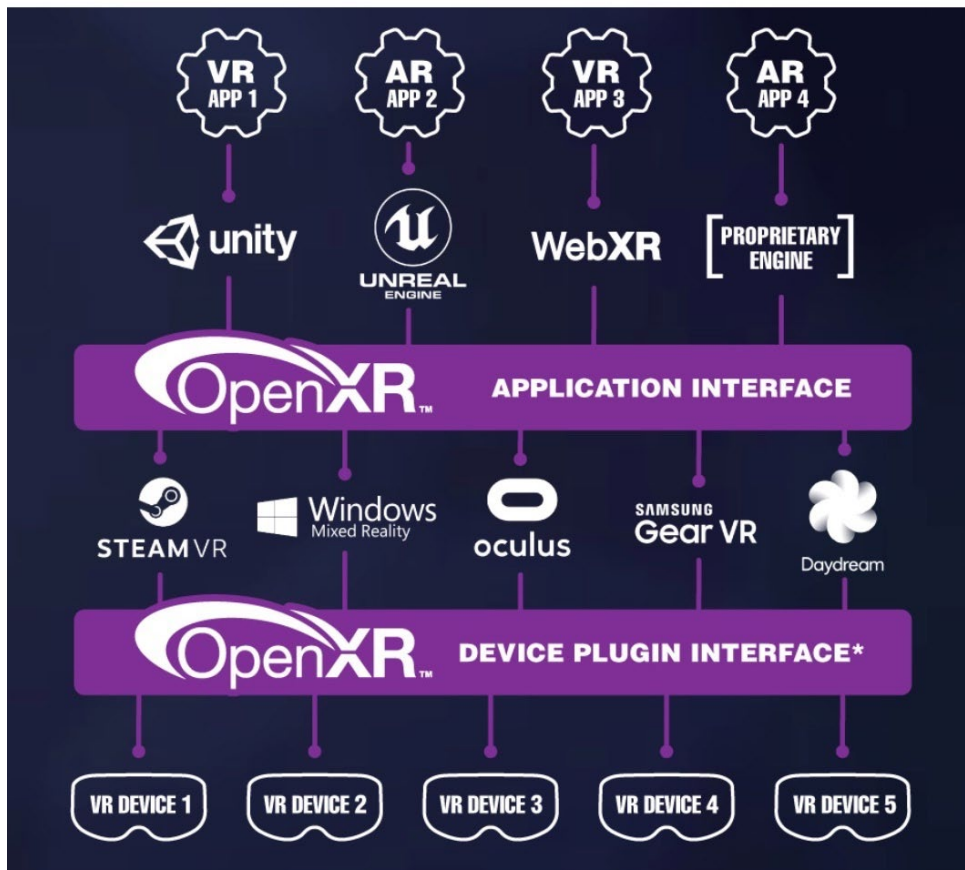
Image from Khronos Group website

Image 22- Layers of software abstraction. Source: - Khronos Group website, https://www.khronos.org.

OpenXR is an Application Programming Interface (API) for XR applications.[10] It is an open, royalty-free standard developed by Khronos that aims to allow developers to seamlessly target a wide range of augmented and virtual reality devices. OpenXR is the interface between an application and an in-process or out-of-process "XR runtime system." The runtime may handle such functionality as frame composition, peripheral management, and raw tracking information. Optionally, a runtime may support device layer plugins which would allow access to the artwork on a variety of hardware across a commonly defined interface.

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[10] XR refers to a continuum of real-and-virtual combined environments generated by computers through human-machine interaction and is inclusive of the technologies associated with virtual reality (VR), augmented reality (AR) and mixed reality (MR).

With version 1.0, OpenXR reaches a maturity point which allows the Khronos Group to guarantee that future versions of the specification will be backward compatible: "With this 1.0 release, the working group will evolve the standard while maintaining full backwards compatibility from this point onward, giving software developers and hardware vendors a solid foundation upon which to deliver incredible, portable, user experiences." (businesswire 2019, n.a)

According to the Oculus developer documentation, the implementation of OpenXR is supported: "As of v19, we are officially supporting OpenXR 1.0 implementation. Developers can now submit their OpenXR apps to the Oculus Store" (Oculus VR 2020). However, according to the Unity documentation, regarding the Oculus Quest/Quest 2 it is not yet fully supported (Unity 2021). However, since the current case study only makes use of the most basic features within typical VR environments, migration to OpenXR could be a distinct possibility that would improve the work's longevity and make it more adaptable to display on different devices.

As described in Appendix A.8, periodically upgrading all software components to a Long Term Support (LTS) version, will help on the prevention of software obsolescence, and going for LTS instead of the latest versions will provide better documented support for migration, while minimizing the occurrence of bugs due to insufficiently tested software. LTS versions tend to have wider approval from the community of software developers and users, and are therefore the recommended path to follow whenever the project does not require specific Beta features only available on the latest versions. Further, the subject of LTS support was widely discussed during the roundtable during which there was general agreement concerning its benefits as an adequate migration strategy.

4.3. Applied Measures

Over the course of this project, several of the conservation strategies described above have been explored in order to secure the artwork *100 Jaar Vrouwenkiesrecht* for the future. As a first step, three disk images from the Oculus Quest were created after which four different migration strategies were tested. These different processes and results will be discussed in further detail in the following subsections.

During the course of this research, the process of upgrading all components, removing specific Oculus dependencies and installing openXR has been tested to assess the difficulties. However, the migrated version of the project was not tested on any HMD (Oculus or others).

4.3.1. Disk Imaging

As an important documentation measure, during the scope of this project, several disk images were created (see table below).

File	Content description	Size
100JVK201926f1.dmg	Unity project, including all assets and required packages	2.0 GB
201926f1.dmg	Unity Editor with Android apk and OpenJDK	5.2 GB
100JVK9336.dmg	Final Build (installable in the Oculus device)	73 MB

Table 3-Overview of disk images made of the work

As a comparison, a .dmg image containing the apk build, editor, apk, openJDK, and the entire Unity project is 7.5 GB, while an uncompressed .tar archive would occupy 7.5 GB. A compressed .tar.gz

version of the same files occupies only 3.3 GB, while a .zip compressed version would take up 3.4 GB (both close to the .dmg image size but without the benefits of the imager integrity check capabilities of the DMG image format). The following provides a brief explanation of how .dmg images can be created and monitored.

The .dmg images can be created from MacOS using the following command:
(similar tools are available for Linux and Windows platforms)

```
hdiutil create \
  -volname 100JVK \              # partition name
  -fs UDF \                      # (Universal file format)
  -srcfolder /Path/to/Backup \   # (Files to include in the image)
  -format UDRO \                 # UDIF read-only image
  100JVK.dmg                     # image file name
created: 100JVK.dmg
```

Table 4-Command for MacOS to create .dmg image
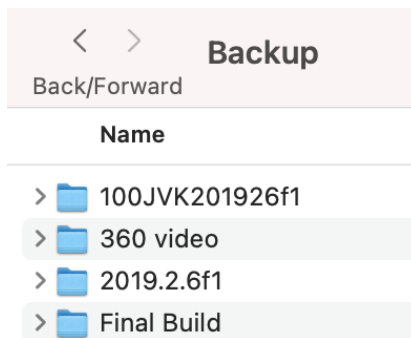
Image 23-Screenshot showing backup of artwork

Periodic monitoring of the .dmg file integrity can be achieved by the following command on MacOS (similar tools available for Linux and Windows platforms):

```
hdiutil verify backup.dmg
```

Table 5-Command for MacOS to execute periodic monitoring

In terms of storage usage, it is clear that a compressed .tar file gives the most benefits. However, storing compressed files introduces risk, for bit-rot corruption which can make the contents of the file inaccessible.

Tests Conducted
Tests were performed to compare the effects of 1 bit corruption on different formats. Altering 1 bit of the dmg file, still allowed it to be opened and the disc image explored, as it includes a filesystem and an index, but the checksum verification revealed the existence of corrupted data.

MacOS, by default, will not allow users to open an image with an invalid checksum, but this feature can be disabled, simply by typing the following command on a terminal.

```
defaults write com.apple.frameworks.diskimages skip-verify -bool YES
```

Table 6-Command to allow MacOS to open an image with an invalid checksum

Both .tar and compressed .tar.gz archives failed to open after altering 1 single bit. The same negative results were obtained from the zip compressed file.
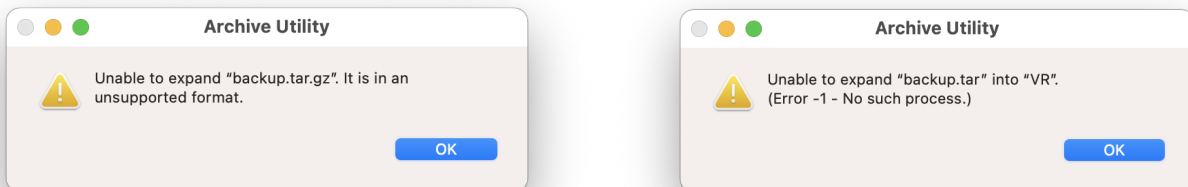

Image 24 and 25-Screenshots of error messages returned after trying to open altered .tar and compressed .tar.gz archives

```
$ hdiutil verify backup.dmg
calculated CRC32 $E3692FDE, expected   CRC32 $24F75CF7
hdiutil: verify: checksum of "disk images/backup.dmg" is INVALID
```

Table 7-Checksum verification of .dmg image

If needed, .dmg images can be easily converted to .iso by typing the following command:

```
hdiutil convert backup.dmg -format UDTO -o backup && mv backup.cdr
backup.iso
```

Table 8-Command to convert .dmg images to .iso

Yet, it should be noted that the .iso image file will require more storage capacity than the .dmg format.

```
$ du -sh ./backup*

7.7G    ./backup            # original folder
7.5G    ./backup.dmg        # DMG image
9.0G    ./backup.iso        # ISO image
7.5G    ./backup.tar        # uncompress TAR archive
3.3G    ./backup.tar.gz     # compressed TAR archive
3.4G    ./backup.zip        # compressed ZIP file
```

Table 9-Overview of storage requirements when comparing different formats

As stated before, the Oculus Quest is a standalone device that unlike most VR headsets does not require a computer to operate. Instead, the hardware is not unlike that of a smartphone, where it's storage component chip is integrated as part of the motherboard, and is not meant to be physically accessed or replaced. Thus, creating a full disk image copy from the Oculus Quest headset by means of physically cloning the storage device, which is as a standard data forensics strategy, could potentially compromise the integrity of the hardware if attempted without the appropriate skills. On the other hand, making a full disk image of the Oculus Quest, including system files, could be possible through a terminal access with root permissions. The Android Debug Bridge (ADB) is a multi-platform command line tool that allows such tasks by providing a connection mechanism between a computer and Android device. Without root permissions, it is still possible to access application data and logs from the Oculus Quest for backup purposes. Yet, the Oculus Quest needs to be set to Developer Mode in order to use the ADB. This can be enabled with the help of the Oculus App run on a phone or tablet, or with the Oculus Developer Hub software available for Windows or MacOs. See Appendix A.6 for more information about using ADB.

Once the data present on the Oculus Quest was extracted using ADB, a disk image was created. The disk imaging process can be done in many different ways and every operating system provides different tools to achieve the same result. During the tests, MacOS Catalina (version 10.15.7) was used to perform the creation of archivable disk images. See Appendix A.7 for step by step description for the creation of the disk images.

4.3.2. Tested Migration Strategies

Loading the original software build onto a newer device
As described in Section 2.1, the artwork was delivered with Oculus Quest goggles running on a 2019 firmware version. Within the digital files provided by the artist, was also an apk build, corresponding to the application running on the original goggles (see the comparison below). The provided apk file compiled from the Unity code was successfully migrated to a 2021 Oculus Quest 2, running the latest firmware (29.0.0.65.370). The firmware version in question was dated Sun May 9 20:25:04 PDT 2021.

Rebuilding the application package from the original code
In order to check whether the submitted application package file matched with the source code of the work, a new build of the project file was performed. The new apk file compiled from the source code was installed and tested on an Oculus Quest 2 device, resulting in a user experience very similar to the original.

Rebuilding the application package with a newer version of the engine editor
The code of any Unity project is always linked to a specific version of the Unity engine. Therefore, the next approach was to rebuild the application package based on the current version of the engine editor (2021). However, the upgrade of the Unity engine resulted in a variety of conflicts that did not allow the creation of a new build without needing to address every issue.

Migrating the application to OpenXR
The last migration step was to migrate the application to an open standard. This required migrating the work to a newer version of the editor, since the libraries for OpenXR are only available from the 2020.2+ version of the editor. The migration to the 2021 version of the editor required modifications to the code to keep it functional. See Appendix A.8 for more information on upgrading the Unity editor version and enabling OpenXR.

5. Outlook

At the end of the roundtable, discussion turned to the conservation and preservation outlook for VR artworks. Despite the preservation obstacles brought up earlier the general mood of the expert's assembled seemed to be hopeful. That even if VR artworks were not able to be preserved with their original hardware/software the advance of technology would open up new options for recreating the artwork and therefore maintaining public access to it. This final section addresses the outlook for Justin Zijlstra's *100 Jaar Vrouwenkiesrecht.* To do which considerations concerning the work's distribution and future presentation have been explored, as well as suggestions given. Recommendations have been supplied in the last subsection for areas in this research that require further investigation before decisions can be made.

5.1. Distribution and Future Presentation

LIMA is a pioneer and centre of expertise in the fields of preservation, research and distribution of media art. Distribution raises awareness and interest in artworks by increasing accessibility. At this current point, distribution and future presentation of VR works such as *100 Jaar Vrouwenkiesrecht* requires the existence of compatible hardware i.e. an Oculus Quest or Oculus Quest 2. As mentioned before, migration to OpenXR would enable the artwork to be reproduced on a wider range of headsets.-

To distribute the exported apk file, the technical specifications of the compatible hardware must be included, as well as step by step instructions for its installation. A digital signature of the apk file can be generated for copyright purposes and a user license should be drafted before sharing access to the application file.

It is not possible at this time to automatically include the artwork in an online collection database or to rebuild the project so that it is compatible with multiple VR systems. The aim here was to compare with video works, where previews and re-encoding tasks can be automated to generate several distribution files.

Distribution of the 360º video version of this work presents comparatively fewer challenges. There are several ways for web-based video players to correctly interpret the metadata of 360º videos making it easy to present on different web-based platforms and to include watermarks for distribution, it is possible to create a 360º image that shows at least one watermark in any possible direction then overlap it with the original video. Watermarked images must be mapped to an equirectangular projection format to be correctly visualized in the final product. Watermarks are recommended for consideration to protect the work against illicit distribution or alteration.

Installation of the artwork, should follow the documentation of the work from past presentations and be conducted in conversation with the artist. Further, any changes to the installation should be discussed with the artist and the institution in ownership of the artwork, Atria. Possible changes that should be discussed before implementation could include presenting the artwork on different hardware or presenting the work without the "tower viewer." This research has attempted to describe

in as great a detail as possible the current status of the work to be used as a tool when considering the work's future presentation.

5.2. Recommendations

As mentioned in Section 4.3.1, a disk image was created containing the original version of the software. This included the required plugins, development environment, game engine, and Java SDK, as the frozen versions used by the artist when exporting the provided artwork. The migration strategy described in Sections 4.2.5 and 4.3.2 resulted in an entirely new project and software package. The creation of additional archival images to preserve the migrated version is recommended. This should be done after making sure the migrated version runs on the device with no modifications in the experience.

Some decisions must take place regarding the formatting for archiving software code, plugins and engines. LIMA uses .tar (Tape archival format) files to store the content on LTO tapes. During this research, other formats were tested as possible alternatives. DMG image files provide a self-contained integrity verification, and allows access to the content even after bit-corruption. Integrity of individual files can be monitored based on pre-stored MD5 checksums. Tests were made to verify the accessibility to artificially corrupted data (1-bit-flip) on different archiving formats (refer to Section 4.3.1). As a standard strategy, two copies of the data should be stored on LTO tapes, and a third "hot" copy should remain available for rapid access on a file server for distribution purposes.

Lastly, as has been mentioned prior in Section 3.5, it is necessary to interview the artist further about the installation options for the work. This interview could benefit from the inclusion in discussion of past presentations, resulting in the generation of iteration reports. Any generated iteration reports should be kept on file for the artwork as reference and an iteration report should be written for all future exhibitions. By doing so, documentation of the installation choices for an artwork can be plotted and understanding can be reached concerning the degree of permissible change.

Recommendation Checklist for the Preservation of *VR artworks*

☐ Acquire two sets of compatible HMDs upon which the VR artwork is installed and running (In this case, Oculus Quest 1 and 2 are both compatible with the existing apk file).

☐ Make sure no automatic updates can occur by disabling all wireless communications

☐ Removing the batteries from the device when not in use

☐ Obtain a 360º video from the artwork. This can be done either by creating a 360º video from the source code, or by making a screen recording of the device during usage. Preferably, the artist should be requested to do this.

☐ Create copies of the 360º video at the highest available resolution and using a lossless, uncompressed video format, such as .avi or Ffv1.

☐ Create detailed documentation including:
  – step-by-step compilation and installation instructions,
  – minimum requirements for the software environment,
  – a list of compatible hardware,
  – minimum hardware requirements,
  – on / off and troubleshooting guidelines for exhibitions

☐ Interview the artist about the artwork and the artist's intended interaction.

☐ Obtain the original source code from the artist, if available.

☐ Create a Disk Image including the project source code and required plugins, add-ons and software development environment.

☐ Migrate the software to Open Source and Long Term Support solutions wherever possible and test compatibility with current off-the-shelf HMDs (See Appendix A.8).

☐ If the previous step was applied, create a list of hardware alternatives and make new Disk Images with the new Source Code, Dependencies, Software environment and most recently exported application.

☐ Store the Disk Image files in two separate platforms (offline media, such as CD, DVD, SSD drives or LTO tapes are valid options) and periodically monitor their integrity and re-write if necessary.

6. Conclusion

At the end of the roundtable Tjarda de Haan, former head of collections at Atria, spoke of the organization's intention with the commission of *100 Jaar Vrouwenkiesrecht*. She talked about how they had intended it to be a time capsule in two senses: one where it allowed you to look back and be part of the women's suffrage movement of the 1860s and another that would allow viewers in the future to have this same experience. This project has attempted to preserve the work in both of these senses, investigate the findings of the "White Paper" and answer the research questions posed by LIMA. To do this it has provided an in-depth identification of the artwork, it's documentation, preservation concerns, those conservation measures applied and given the outlook for the work's distribution as well as future presentation. Not only this, but it has attempted to put forward the current standards for sustainable storage of VR artworks and compare them with LIMA's approach to gain context about how LIMA's workflow can be adapted to consider incoming VR artworks. This paper has further addressed how the experience and interaction of the work can be mapped, how to understand the different versions of VR artworks as well as how the work can best be preserved. Consequently, this research has found that, although this case-study does not fully represent the complexities of many VR artworks, it provides numerous case-specific considerations when framed by the findings of the "White Paper."

This project ends with the publication of this paper. Yet in the future, the artist still needs to be interviewed in greater depth concerning the presentation as well as conservation of his work and further research is also required in regards to:

- Creating a standardized method for describing user-experience of VR artworks,
- Exploring the conservation of other artworks in the field of XR,
- Studying the potential of the web browser as a platform for exporting interactive VR artworks,
- Studying the porting of devices to open source systems for increased accessibility.

7. Works Cited

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8. Appendix

A.1   Audio track transcription

Beeld: Man verlaat het huis om te stemmen.
Vrouw blijft binnen.

Een vraag die ik heel vaak krijg is:
Hoe vind ik mijn stem?

Voordat ik je daarmee ga helpen,
wil ik twee dingen zeggen:
      1. Als een geluid uit jouw mond komt, is het van jou.
      2. Er bestaat niet zoiets als jouw ene echte, jouw perfecte stem,
      er bestaat wel gezond en ongezond stemgebruik,
      vrij en onvrij.

Wat jij ervaart is een gebrek aan resonantie.
Jij hebt het gevoel dat jouw stem niet gehoord wordt,
dat is het, toch?

Beeld: vrouw dwaalt door de gangen.

Ik ga jou vandaag iets leren
waar ik zelf bij zweer.
Ik gebruik deze routine altijd als warming-up,
before I speak up.

We gaan een strijdlied zingen.
Ik hoor je denken:
Waarom zou ik zingen als ik wil spreken?
'Because: you have to go off key to find your true voice.'
Hoor je?
Jij moet ruimte opeisen,
ook voor je valse, je woeste tonen.

Dit strijdlied is in 1911 gecomponeerd
door de Engelse Suffragette Ethel Mary Smyth.
En de boodschap is perfect voor ons.

Sluit je ogen. Take a deep breath.
      (ademteug)
We beginnen met neuriën,
we laten het trillen in ons,
we trillen ons als het ware los.
      (neuriën)

Beeld: de straat op

Voel je wat ik bedoel? Ja toch?
Dan voegen we nu woorden toe.
Vrees niet, je kent de tekst. Jij bent een goede luisteraar,
you've heard this song before:
    (Voorzichtig:
    Voort! Voort! Met heil'gen drang!
    Wijd waait ons vaandel in 't blauw van de luchten!)
Laten we het nog 'n keer doen.
Voordat we kunnen resoneren in anderen,
moeten we resoneren in ons:
    (Minder voorzichtig:
    Voort! Voort! Met heil'gen drang!
    Wijd waait ons vaandel in 't blauw van de luchten!)

Beeld: demonstratie

Voordat we verder gaan wil ik je nog iets op het hart drukken.
Bewaar je stem niet voor speciale gelegenheden,
wacht niet tot je een podium hebt gevonden.
Gebruik 'm op straat.
In je woonkamer, kantoor,
het treinstation.

Genoeg gepreekt.
Ik denk dat jij wel weet wat je ermee moet doen.
Nog één keer diep ademhalen:
    (ademteug)
Gebruik je hele lichaam.
Let's go:
    (Uit volle borst:
    Voort! Voort! Met heil'gen drang!
    Wijd waait ons vaandel in 't blauw van de luchten!
    Wie ervoor streden
    wie ervoor leden,
    hoor haar stem en blij klinkt ons koor:
    'Voor waarts! 't Zwelt aan steeds; hoor!
    Stormwind van vrijheid, de wereld door!)

Ik wil graag eindigen met een quote van een beroemde schrijver:
'A voice is a human gift; it should be cherished and used.
Powerlessness and silence go together.'

Tot volgende keer,
de zoektocht naar een stem duurt langer dan tutorial,
maar hé,
je hebt iets in beweging gezet,
je bent begonnen.

A.2 Questions and Answers from Interview by Pablo Uceda Gomez with Justin Zijlstra on October 29th 2019

Could you briefly describe the key elements of your work?

As a cross-over between a tower viewer and a peep-box the installation is an immobile object and calls upon the participants' curiosity to take a look. Once the participant looks through the viewer the experience starts. Set across a static timeline the narrator takes the participant through the 3 minute story while providing the freedom of a 360° view within the virtual world. Sound comes from the built in speakers or attached headphones.

What is the added value of VR for heritage institutions?

Well, it could be used to recreate certain historical events or objects and make them easily shareable through the internet so that archives could be examined anywhere.

What could VR bring to recreation of heritage?

It sparks the imagination and interest, bringing to life archived footage.

How can VR help history telling in the context of exhibitions?

It could make it more accessible, being virtual an exhibition could be experienced anywhere. Also as stated earlier VR can put you right into the historical event.

What do you see as the biggest challenge(s) to maintain the ability to present the artwork in the future?

Technology surpassing the ability to play it on newer systems, and the current carrier breaking and becoming obsolete.

A.3   Oculus Quest initialization instructions

Remove oculus quest from holder

Hold the power button 2 seconds

Follow setup of the oculus (for roomscale guardian and draw a guardian for a couple of meters)
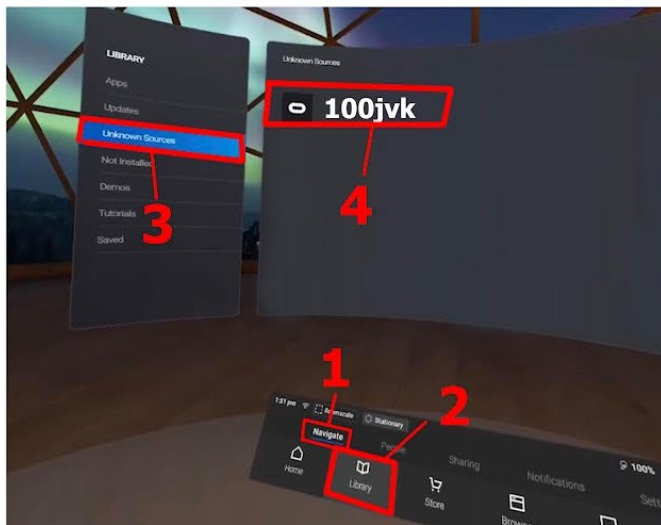
Inside the "room":
(with either controller)
1 click "Navigate"
2 click "Library"
3 click "Unknown Sources"
4 click "100JVK"

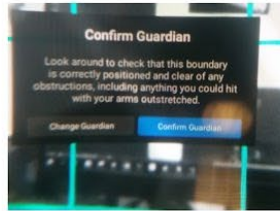**Shut off:**
Hold power button 2 seconds
Click "power off"
Or:
Hold power button 10 seconds

A.4 Roomscale Guardian setup instructions

Roomscale guardian :

If there is a guardian and it works, just confirm.

If not and you change or make a new guardian folow the oculus steps:

Conform floor level:
look at the floor the + signs
should be at floor level as indicated
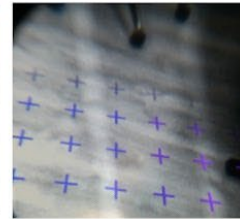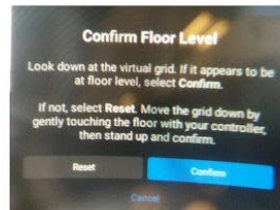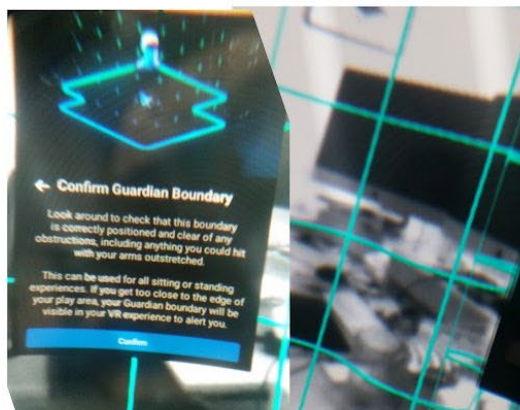
Then confirm

Define Play Area

Draw a circle around the installation of a couple of meters.

The circle fills it self in if closed
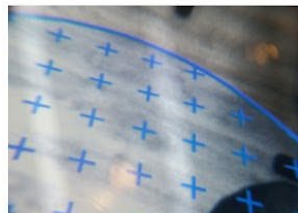
A vertical grid will be created confirm and start the project

A.5   Notes on play area setup and guardian boundary

As soon as the goggles are booted up, the following warning message appears: "Guardian not found. Please create a new guardian boundary for the play area", followed by a blue rectangle which reads "Create new guardian". Selecting this brings up a next message: "Confirm floor level. Look down at the virtual grid, if it appears to be at floor level select confirm, if not, select reset, move the grid down by gently touching the floor with your controller then stand up and confirm." With the options "Reset" or "Confirm".

After confirming, this message pops up: "Define play area. Point your controller at the floor, then press and hold the trigger to draw along the boundary of your cleared play area. We recommend a play space size of 6.5 feet by 6.5 feet or greater for room scale experiences." At this point, when pointing the controller down, a grid of white crosses appears and if the user moves their head, then the display message moves along. At the bottom there is the option to skip for sitting or standing experiences only (which is the case for this artwork). After hitting skip, a blue and cylindrical grid appears all around the user, similar to a virtual cage.

Finally, this last message comes up: "Confirm stationary guardian. Look around to check that this boundary is clear of obstructions, including anything that you could hit with your arms outstretched. This stationary guardian is for sitting or standing experiences only. If you get too close to the edge of your play area, your guardian boundary will be visible in your VR experience to alert you." After hitting the "Confirm" option the user enters a virtual room.

Note: if the user leaves the defined play area, then a warning message appears: "Return to Play Area. You've left your guardian boundary. Please return or create a new boundary." The options are either to create a "Stationary Boundary" or a "Roomscale Boundary". If the user returns within the boundaries of the original play area, then the warning message automatically disappears.

A.6   Android Debug Bridge

In order to copy the data from the Oculus into a separate computer, the Android Debug Bridge was used. ADB is a command line tool which is included in the Android SDK and is the main tool used to communicate with an Android device. The official ADB documentation can be found here: https://developer.android.com/studio/command-line/adb

In order to connect to the Oculus with adb, it is required to use the Oculus app to enable developer mode. To connect to a device, connect to the oculus through a USB cable, open a terminal or command line and type:

```
adb devices -l
```

This will bring up the list of connected android devices. In order to make get the Oculus content into the PC, run:

```
adb pull -a /storage ~/oculus-backup
```

The inverse `adb pull` command can be used to copy files from the computer to the Oculus Quest device.

Ideally, rooting the device would allow to synchronize the entire content from the device, but `adb root` command is not allowed for production builds.

A.7   Creation of disk images

In MacOs, It's possible to create a disk image from the copied folder, by executing the following steps:

In the Disk Utility app on your Mac, choose File → New Image, then choose Image from Folder.
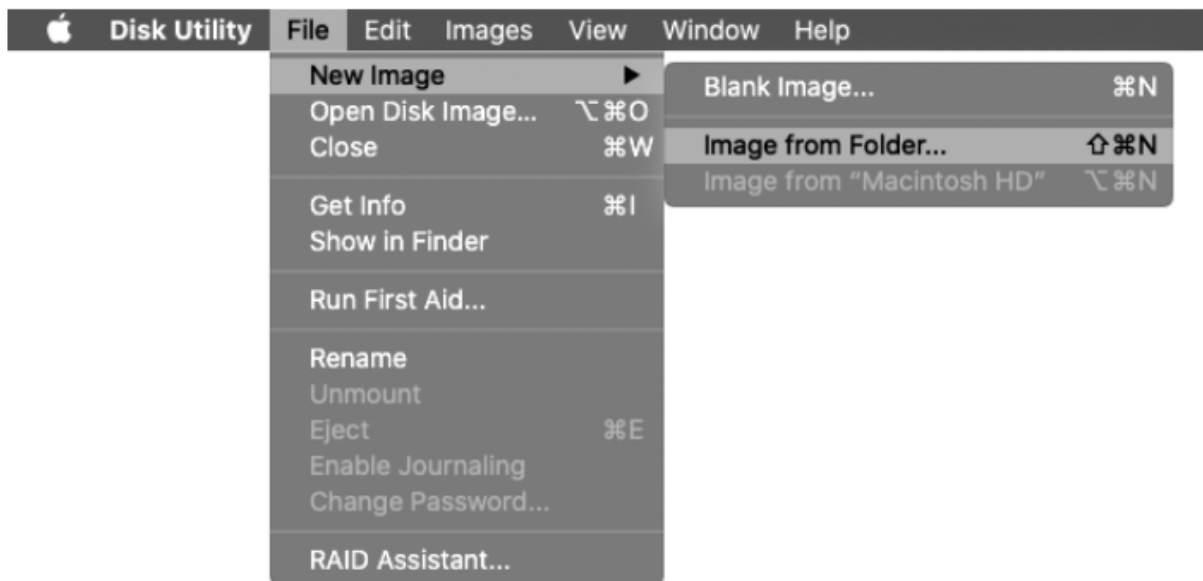
Select the folder where the files have been copied.

Enter a filename for the disk image (add optionally, tags), then choose where to save it.

Since this image is meant for preservation, choose a **read-only** image format, to ensure no changes will be made to the contents.

This will end with an **oculus-backup.dmg** file in the home folder.
In order to convert it to an ISO image, follow the next steps:

After double-clicking on the oculus-backup.dmg file, a new volume is mounted, containing all the files copied from the android device.

This process can also be performed by means of the hdiutil command line tool available for MacOs.

```
hdiutul create \
  -volname 110JVK \              # partition name
  -fs UDF \                      # (Universal file format)
```

```
   -srcfolder /Path/to/Backup \      # (Files to include in the image)
   -format UDRO \                    # read-only
   100JVK.dmg                        # image file name
created: 100JVK.dmg
```

The new image contains a checksum of its contents, and it allows future validation.

```
hdiutil verify 100JVK.dmg
. . .
VALID
```

The uncompressed .tar packages are created the following way:

```
tar -cf archive.tar /path/to/directory
```

This command creates an archive, but doesn't compress the contents.

A.8   Upgrading the Unity editor version and enabling OpenXR

To upgrade the editor version, first install the Editor from the Menu. Choose the latest version with the LTS (Long term support) label. Make sure to enable Android Build Support with Android SDK and OpenJDK enabled.

Once a version higher than 2020.2 is installed, open the UnityHub and locate the project.
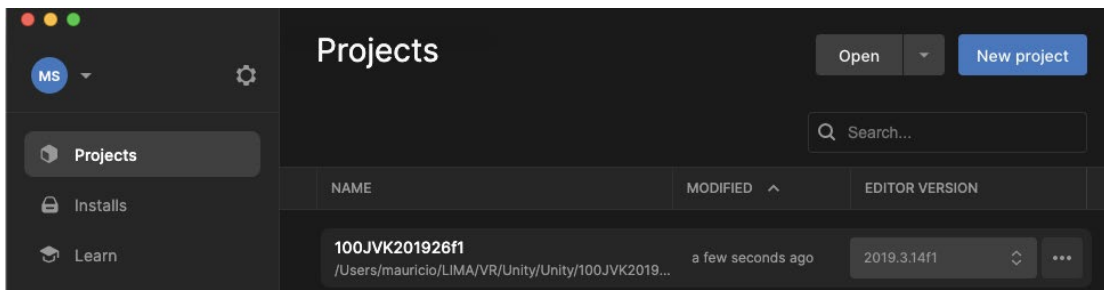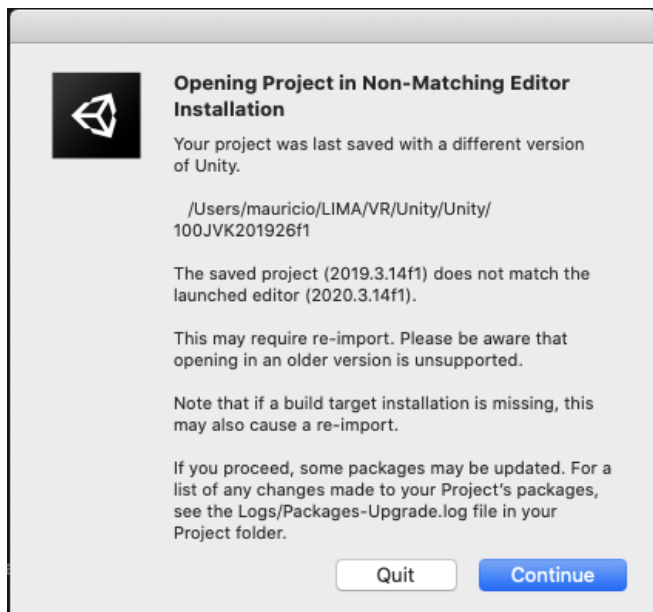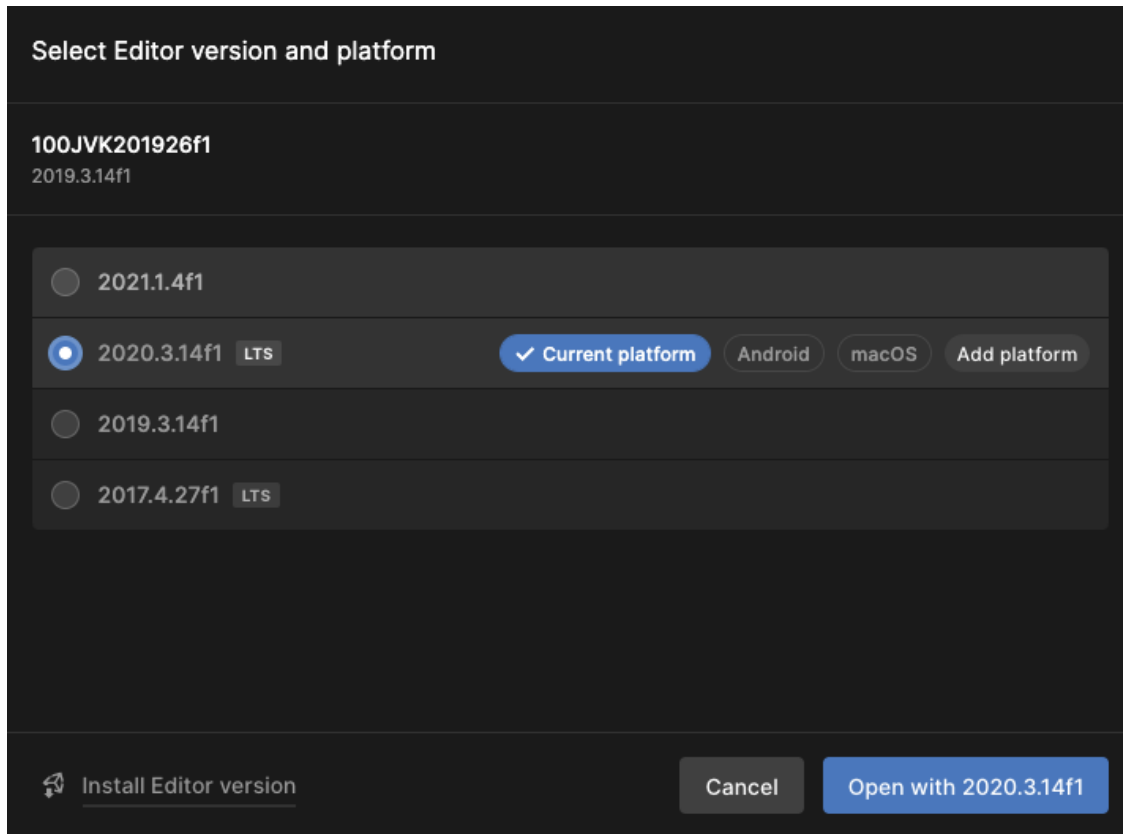
Note that the original projects uses the "Oculus Android" Package, that was deprecated in 2021 in favor of the XR Plugin System

Oculus Android

Version 2.38.4 - November 26, 2019

Name
com.unity.xr.oculus.android

Links
View documentation
View changelog
View licenses

Author
Unity Technologies

Registry Unity

Published Date
November 26, 2019

*** IMPORTANT : READ ME ***

This package is deprecated and will be removed in Unity 2020.1.

If you are using this package, consider upgrading to the XR Plugin System. More information on the XR Plugin System can be found here:
https://docs.unity3d.com/2019.3/Documentation/Manual/XR.html

This package contains the necessary components required to use the Oculus Virtual Reality SDK on Android. By using this package, you will be able to deploy and run your applications on Oculus supported devices.

Dependencies

No dependencies

Oculus XR Plugin

Version 1.9.1 - May 11, 2021   `2019.4 verified`

Name
com.unity.xr.oculus

Links
View documentation
View changelog
View licenses

Author
Unity Technologies

Registry Unity

Published Date
May 11, 2021

Provides display and input support for Oculus devices.

Dependencies

XR Plugin Management   4.0.1
Unity UI   1.0.0   (installed ✔)

XR Plugin Management

Version 4.0.7 - July 12, 2021   [2019.4 verified]

Name
com.unity.xr.management

Links
View documentation
View changelog
View licenses

Author
Unity Technologies

Registry   Unity

Published Date
July 12, 2021

Package that provides simple management of XR plug-ins. Manages and offers help with loading, initialization, settings, and build support for XR plug-ins.

Dependencies

Subsystems	1.0.0	(enabled ✓)
VR	1.0.0	(enabled ✓)
XR	1.0.0	(enabled ✓)
XR Legacy Input Helpers	2.1.7	
Subsystem Registration	1.0.6	

To enable OpenXR in the project, follow the steps below:

6. Install the **OpenXR Plugin** package from **Package Manager** (Select the **Gear** icon in the **Package Manager** UI to bring up the **Package Manager** settings drop down and select the **Advanced Project Settings** item. This will take you to the **Package Manager** settings page where you can enable preview packages.).
7. Open the **Project Settings** window (menu: **Edit > Project Settings**), and select **XR Plug-in Management**.
8. Enable the **OpenXR** option and any **Feature Sets** for the runtimes you intend to target.
9. In the **OpenXR > Features** tab, select the interaction profile of the device you are testing with.
10. In the **OpenXR** tab, make sure the current active runtime is set to the hardware you are testing with.

A.9   360º video metadata

360 Video:
Type: mp4
Encoding : h264
Data rate: 10343 kb/s
Duration: 00:03:26.68
Resolution: 2048x4096
Frame rate: 30 fps
Stereo 3d type: top and bottom
Projection type: spherical, equirectangular

Audio: stereo
Coding: AAC (Lossy compression)
Data rates: 317 kb/s

Sampling rate: 48000 Hz

```
Metadata:
    major_brand     : mp42
    minor_version   : 0
    compatible_brands: mp42mp41
    creation_time   : 2019-09-25T10:07:37.000000Z
  Duration: 00:03:26.68, start: 0.000000, bitrate: 10663 kb/s
    Stream #0:0(eng): Video: h264 (Main) (avc1 / 0x31637661), yuv420p(tv, bt709), 2048x4096, 10343 kb/s,
30 fps, 30 tbr, 30k tbn, 60 tbc (default)
    Metadata:
      creation_time   : 2019-09-25T10:07:38.000000Z
      handler_name    : ?Mainconcept Video Media Handler
      encoder         : AVC Coding
    Side data:
      stereo3d: top and bottom
      spherical: equirectangular (0.000000/0.000000/0.000000)
    Stream #0:1(eng): Audio: aac (LC) (mp4a / 0x6134706D), 48000 Hz, stereo, fltp, 317 kb/s (default)
    Metadata:
      creation_time   : 2019-09-25T10:07:38.000000Z
      handler_name    : #Mainconcept MP4 Sound Media Handler
```

A.10 MD5 Checksum

In order to generate a checksum of every file, in coordination with full path and file size information, the following script was created:

archive.sh

```
#!/bin/sh

abspath() { old=`pwd`;new=$(dirname "$1");if [ "$new" != "." ]; then cd $new;
fi;file=`pwd`/$(basename "$1");cd $old;echo $file; }
find `abspath $1` -type f -print | xargs -I% sh -c 'file="%";hash=`md5 -q
"$file"`;filedata=`stat c "$file" | cut -d'/' -f1`;echo "\"$file\" \"$hash\"
$filedata";' 2> /dev/null
```

Usage (runs on MacOS):

```
chmod +x archive.sh
./archive.sh PATH_TO_FOLDER > out.txt
```

Example of the output:

"/Users/.../LIMA/VR/FinalBuild/100JVK9336.apk" "59b860599f2e2fbaba74dfa8904affc6" 16777222
44261181 -rwx------ 1 {owner} staff 0 76302447 "May 7 01:36:57 2021" "Jan 17 16:39:51 2020"
"May 7 01:37:37 2021" "Jan 17 16:39:51 2020" 4096 149248 0

A simpler version to generate a list of files with their respective Md5 hashes could be:

```
find PATH_TO_FOLDER -type f -print | xargs -I% sh -c 'echo "$(md5 -q "%")
%"'
```

A.11 Bitflip

In order to test the effects of bit-rot data corruption, the following script was created to randomly alter a specific bit in a file:

bitflip

```python
#!/usr/bin/env python3
"""Toggle the bit at the specified offset.
Syntax: bitflip filename bit-offset"""

import sys
fname = sys.argv[1]
# Convert bit offset to bytes + leftover bits
bitpos = int(sys.argv[2])
nbytes, nbits = divmod(bitpos, 8)

# Open in read+write, binary mode; read 1 byte
fp = open(fname, "r+b")
fp.seek(nbytes, 0)
c = fp.read(1)

# Toggle bit at byte position `nbits`
toggled = bytes( [ ord(c)^(1<<nbits) ] )
# print(toggled) # diagnostic output

# Back up one byte, write out the modified byte
fp.seek(-1, 1)  # or absolute: fp.seek(nbytes, 0)
fp.write(toggled)
fp.close()
```

Make sure that the file is executable from any folder

```
chmod +x bitflip && mv bitflip /usr/local/bin/bitflip
```

Usage

Example: flip the first bit of a file

```
## bitflip /path/to/file bit-offset
bitflip backup.tar 1
```

A.12 Summary of Roundtable Participants

The roundtable, described throughout this paper, was held on July 20th, 2021 and addressed the preservation of VR through a series of presentations by other experts in the field accented by an extended discussion section (see VR_Roundtable_Summary_20-7-2021 for extended summary). Those presentations included in the program were: "Diagnosis: Preservation of Virtual Reality Art"

presented by Daphne Kramer; a presentation by Matthieu Vlaminck of current research at the zentrum für kunst und medien karlsruhe (ZKM); "We were looking for ourselves in each other-Melodie Mousset, 2015: 360 degree video recording as a preservation method" presented by Claudia Röck; and lastly "Preservation Strategies for VR: Justin Zijlstra's 100 Jaar Vrouwenkiesrecht (2018-2019) presented by Olivia Brum, Eléonore Bernard, and Mauricio van der Maesen. Including the presenters there were thirteen overall participants in the roundtable these included: Tjarda de Haan (former Head of Collections at Atria), Claudia Röck (Freelance Media Conservator), Matthieu Vlaminck (Digital and Media Art Conservator at ZKM), Zoltan Szegedy-Maszak (Artist and Collaborator with C3 as well as Professor at the Hungarian Institute of Fine Arts), Adam Lockhart (Lecturer in Art and Design at the University of Dundee), Jack McConchie (Time-based Media Conservator at Tate), Tom Ensom (Digital Conservator at Tate), Morgane Stricot (Senior Conservator and Head of Digital Conservation at ZKM), Dragan Espenchied (Preservation Director at Rhizome), Olivia Brum (Post Masters' Student at the University of Amsterdam and Graduate Intern at LIMA), Mauricio van der Maesen de Sombreff (Artist, Computer Scientist as well as Telecommunications and Electronics Engineer), Eléonore Bernard (Freelance Media Conservator) and Gaby Wijers (Director at LIMA).

Credits

Research conducted as part of LIMA's research on preservation of VR artworks.

Report by:
Olivia Brum (Researcher and Graduate Intern)
Mauricio van der Maesen de Sombreff (Technical Researcher)
Eléonore Bernard (Free-lance Media Conservator)
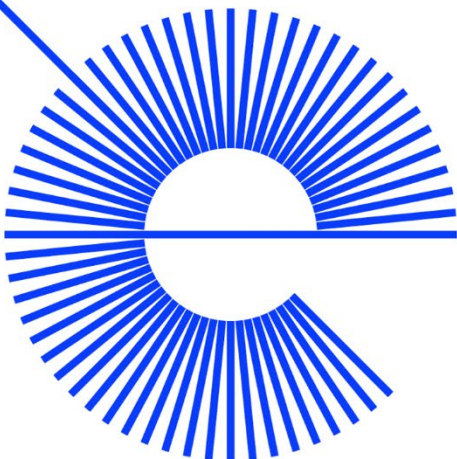Gaby Wijers (Director at LIMA)

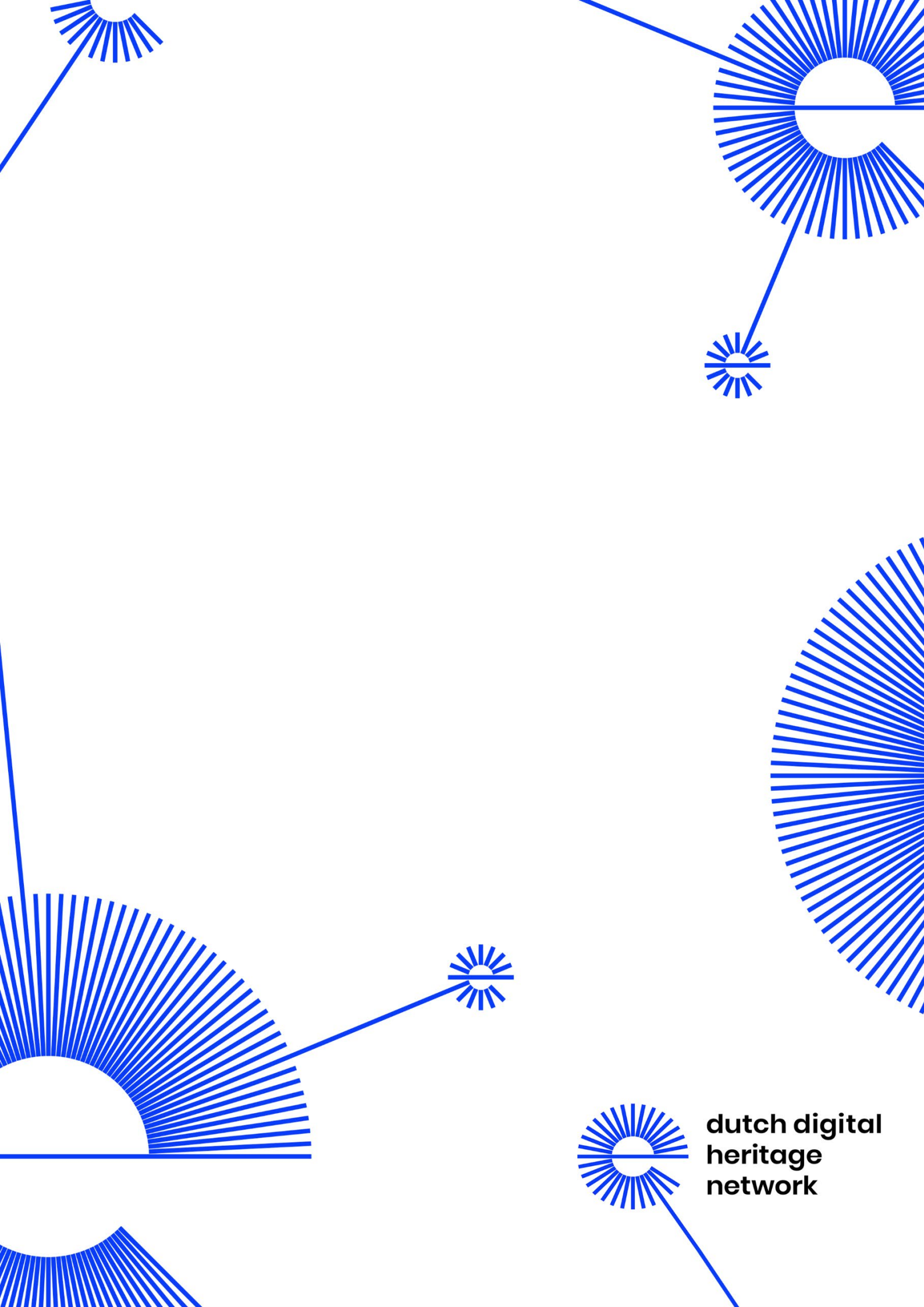**Edited by**:
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