Preserving the emerging: virtual reality and 360-degree video, an internship research report

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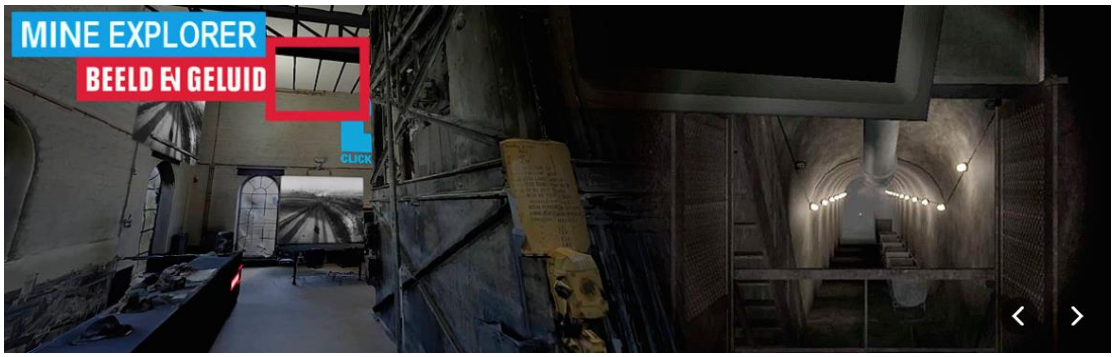

Image: stills from Mine Explorer (Mijn Explorer), 2015, VR application for Oculus Rift. Developed and co-funded by CLICKNL, Jaar van de Mijen and Netherland Institute for Sound and Vision.

Abstract

This research paper explores the preservation of virtual reality (VR) and 360-degree video within the museum/memory institution context. Both formats are of interest to the Netherlands Institute for Sound and Vision (NISV), as they consider how their collection will expand to archive newer moving image formats. Preservation issues such as a lack of standardisation, complex file formats, proprietary software and hardware will be examined as well as some preservation strategies for these emergent technologies.

Keywords: virtual reality, 360-degree video and preservation

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Abbreviations

3D models - three-dimensional models
AR augmented reality
HMD head mounted display
IEEE Institute of Electrical and Electronics Engineers
LED light emitting diode
MR mixed reality
NISV Netherland Institute for Sound and Vision
PC personal computer
VAAR Virtual Reality and Augmented Reality Working Group
VM virtual machine
VR virtual reality

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1. Structure

1.1 Brief outline

This research paper is the result of a 6-week internship undertaken at the Netherlands Institute for Sound and Vision (NISV) in 2017. In collaboration with the Research and Development team at NISV, a plan to define some of the challenges and possible strategies for the preservation of the software component of virtual reality (VR) and 360-degree video were discussed and developed. The internship formed part of a Masters in Cultural Materials Conservation undertaken at the University of Melbourne, Australia and was supported by Mediastages (Netherlands) and the Australian Centre for the Moving Image (ACMI).

1.2 Introduction

Now a widespread application, VR is used across industries as diverse as education, architectural design, gaming (computer and video) and in the cultural heritage sector. A host of organisations such as Facebook (Oculus Rift™), Samsung™ (Gear VR™), Google (Cardboard™ VR platform and Google Daydream™ dock mode) and HTC (Vive™) have all created proprietary VR platforms in recent years. Each company and technological advancement promises to deliver a more immersive experience and platform than the next. The newest developments today - untethered head mounted displays (HMDs), haptic integration and image fidelity technology - may well have been superseded by the time you've read this paper.

While identification of the specific preservation needs and potential solutions for interactive platforms such as video-games and other multimedia formats/artworks have been established both within NISV (de Vos 2013; Glass et al. 2017) and externally (Rhizome n.d; McDonough et. al. 2010) there appears to be very little literature and or standards available to guide preservation for newer, evolving technologies such as VR. While NISV has commissioned, collaborated on and facilitated the creation of several VR pieces and have initiated a pilot program to preserve a body of 360-degree video, they have not yet officially acquired any of these pieces into their collection. This paper aims to describe some of the challenges this may entail.

As technological advances offer new ways of seeing and experiencing, cultural institutions have keenly taken to virtual platforms to illuminate and give access to historic artefacts or create completely new content. One can virtually 'step inside' Van Gogh's Bedroom and or the Eye Film Museum (without ever having been to the Netherlands) with the use of a smartphone, software application and HMD (Vee Jays n.d; Eye n.d). With many museums commissioning and or generating immersive, interactive content, this experience has arguably become an expectation of the consumer and simultaneously generates more visitors for the museum both onsite and online. With such impact this field will inevitably expand in the coming years.

1.3 Framework

A major area of focus for NISV is preservation through innovation and research as well as collaborative projects and standardisation (on an international level). As such, the Research and Development team have amassed a body of knowledge in the form of academic articles, white papers and practical documents pertaining to the implementation of standards throughout the institution. This paper is modelled on such research, especially the preservation work on interactive video and computer games and Jesse de Vos' 'Preserving Interactives. Preserving audio-visual materials in a post-broadcasting paradigm' (2013). It is envisioned that in following a similar structure to de Vos' this research may form the beginnings of a larger preservation plan at NISV at a later date.

The research also assumes a preventive conservation approach which the International Council of Museums - Committee for Conservation (ICOM-CC) suggests encompasses 'all measures and actions aimed at avoiding and minimising future deterioration or loss…carried out within the context or on the surroundings of an item, but more often a group of items, whatever their age and condition. These measures and actions are indirect – they do not interfere with the materials and structures of the items. They do not modify their appearance' (ICOM CC 2008). Applying this to the born digital realm, the ICOM-CC dictum is taken to mean that the fidelity of the original files or 'digital artefact' (Rosenthal 2015) and software are not 'interfered with' or modified, so they maintain their integrity over time. Maintaining the integrity and authenticity of collection content in order to extend its lifetime to ensure the greatest level of access for the longest time also forms the basic tenet of preservation for NISV as stated in their Collection Policy document (2015).

1.4 Research questions

The following series of questions were posed to begin a line of enquiry around the acquisition and long-term preservation of interactive technology for NISV:

- With a variety of complex, interactive digital assets tethered physically and legally to proprietary hardware platforms, how will content remain accessible for future audiences?
- By who will this content be accessed and how?
- For cultural heritage and memory institutions with experience in large-scale, digitisation and preservation can VR and other evolving formats be assimilated into standardised workflows from ingest through to migration and retrieval?
- What strategies are currently available for VR and 360-degree preservation?

1.5 Limitations

As research fellow in Data Curation at the University of Oklahoma Libraries, Zach Lischer-Katz suggests 'any preservation plan, like a data management plan, may best be described as a living document that can change as new data types, uses and stakeholders emerge over time" (2017 p.14). With the expedient nature by which VR technology is evolving, it is necessary to think of this document in a similar manner, to be used and expanded upon in the future.

Time was the major constraint to this project. A deeper exploration of issues such as the legal implications of storing and emulating proprietary VR software and a Dutch collecting perspective as well as a chance to test the durability of VR file formats will make consequent research much richer. This report also concentrates on the preservation of software (not the hardware components that the VR and 360-degree video were played from). This approach again follows de Vos' (2013) and the embedded mass digitisation and preservation practice of an archive.

2. Context

2.1 VR: a brief history

The idea of representing space in an immersive manner is not new. Viewing objects such as hand-held wooden stereoscopes (containing a pair of photographs taken from slightly different angles) were created and used as far back as the 1850's (Uricchio et al. n.d). Static objects like these stereoscopes seemingly transformed 2D planes into 3D spaces. It was not until the 1960's that Ivan Sutherland (one of the godfathers of computer graphics) hypothesised that the computer would provide the next window into the virtual world in his text *The Ultimate Display* (Sutherland 1965). By 1968 he had built one of the first[1] HMD's using simple line drawings with left and right views of computer-generated 3D scenes opening up the possibility for the creation of immersive display (Vince 2004, p.5).

Since Sutherland's prototypes VR technology has advanced in waves. Its evolution and notable examples are too numerous to list here but have been thoroughly documented from prototypes to commercial products (MIT Open Documentary Lab; Virtual Reality Society; Earnshaw, Jones & Gigante; Steinicke 2016). Waves of development have often run counter to mainstream interest; explicable suggests Frank Steinicke, via Bill Buxton's 'long nose concept'. Buxton's theory suggests it can take decades to develop a system from the basic university research to a commercially successful unit or project. The point when an innovation receives mainstream attention is often the space where innovation is at low amplitude and by the time the technology has caught up mainstream attention has waned. This was seen in the 1990's when owing to a spate of science fiction films (such as Lawnmower Man 1992 and its sequel The Lawnmower Man 2: Beyond Cyberspace in 1996) depicting fictional VR systems mainstream interest in VR escalated. As VR was then however, only composed of a few low-resolution colour polygons and unacceptable latency, it created huge and largely unrealistic expectations. The games and programs available in VR were clunky, expensive and therefore relatively inaccessible to the mainstream (Steinicke 2016). The evolution of smartphone technology, powerful hardware as well as affordable and or free HMD's two decades later, made VR platforms available to the mainstream for the first time.

2.2 Terminology

2.2.1 Brief outline

Standardised terms based on the consensus of involved communities can provide a common framework and shared understanding which can aid in the maximisation of compatibility, interoperability, collaboration and or shared resources on an international scale. NISV policy documents and papers are composed using terms and processes defined by the OAIS reference model, and PREMIS - Preservation Metadata: Implementation Strategies. Where possible this paper will also follow this protocol, however many terms have yet to be fully codified in the areas of VR and 360-degree video. A 'device taxonomy and definitions' document is currently being developed by The Virtual Reality and Augmented Reality Working Group (VAAR) within the Institute of Electrical and Electronics Engineers IEEE Standards Association working group but is not available yet (Robertson 2017; IEEE 2017).

2.2.2 Immersion, presence and realities

The defining characteristics of VR and 360-degree video are the sense of 'presence' and 'immersion' they allow a consumer. The manner in which these applications can trick the mind into thinking the

[1] Morton Heilig's 'Sensorama' was another exemplar of VR progress in 1962 (Steinicke 2016).

body is somewhere else, immersed and present in a virtual environment, has been met with much enthusiasm from creators and audiences alike (Kim, Changyu & Kim 2017; Emblematic Group 2016).

The terms VR and 360-degree video have distinct properties that, it will be argued, will require different preservation strategies. Offering what he calls a minimal definition in his text 'Virtual Reality: Definitions, History and Applications', Michael Gigante suggests 'VR is characterised by the illusion of participation in a synthetic environment rather than external observation of such an environment. VR is a 'multi-sensorial experience' often reliant on three dimensional (3D) stereoscopic, head tracked displays, hand/body tracking and binaural sound (Gigante 1993, p.3). Although they will not be discussed in detail here, augmented reality (AR) varies from VR as it adds to or augments 'reality', adding a digital layer to 'reality' such as the digital video that can be taken on a screen like that of smartphone applications, while mixed reality (MR) combines physical and digital worlds often using VR and AR together. The terms '360-degree video' and 'VR' have often perhaps incorrectly been used interchangeably but 360-degree videos are panoramic pictures and videos that have been stitched together. Journalist Stuart Dredge notes of the format, while you can turn your head to look around you, 'these aren't virtual worlds: you don't have free movement to explore them as you do in full virtual reality experiences' (2016).

3. Netherlands Institute for Sound and Vision

3.1 Background

In 1996, following the amalgamation of the Amsterdam based Stichting Film en Wetenschap's collection, the film archive of the Rijksvoorlichtingsdienst and the Broadcasting Museum, NISV was established as a national organisation (NISVb 2015 p.6). NISV's collection contains approximately 70% of the Netherlands audio-visual heritage, the equivalent of more than a million hours of television, radio, music and film. This collection continues to grow with a portion of Dutch public broadcasts received daily by NISV as well as donations and acquisitions.

In 2015 NISV completed a major project (Images of the past. 7 years of images for the future) to digitise most of their legacy material consisting of productions from public broadcasters. The project presented an opportunity to build a solid, theoretical and practical basis for establishing a dedicated preservation structure that can be considered Open Archival Information System (OAIS) compliant (de Jong 2015). The digitised legacy collections forms one part of NISV digitised collections which also consists of 'digital-born, collections ingest of radio and television', 'digital (media) collections from third parties' and 'website and interactive media' (Müller 2016, pp. 264-265).

In their latest strategic preservation framework document: Towards a Multimedia Future in Sound and Vision 2016 - 2020, a desire to move from an audio-visual archive to a multimedia institution, it was stated has compelled NISV to expand its collection to also include 'online content, video art, interactive productions, games and virtual reality' (NISV 2015c, p.16). Growth in these areas make it an ideal time for preservation forward planning through research and pilot programs, some of which were initiated in 2016 to enable re-interpretation of the collection in increasingly new areas.

3.2 Current preservation

NISV follows internationally accepted preservation format guidelines for this purpose and prefers open standard formats, wherever possible. NISV's Digital Preservation Policy suggests a holistic approach to digital preservation where 'all the processes of ingest, storage, preservation and dissemination are interrelated' and include almost all staff across departments (de Jong 2016). There are currently no preservation guidelines for VR and or 360-degree content at NISV but it is hoped that this research can provide a basis for further discussion in preparedness of VR and 360-degree content that will inevitably find its way into the archive.

3.3 VR and 360-degree video projects at NISV

NISV facilitates access to its collection through on-site viewing, digital access, a permanent gallery, temporary gallery and education facilities as well as through collaborative projects making their archive content ever more visible using new technologies. The VR and 360-degree video projects that may be considered as concrete examples for a preservation pilot program are listed in Table 1 below.

Table 1: NISV Projects VR and 360 degree video projects

Title	Credits	Description
Bear 71 **2012** **Format: web**	**Producers:** Loc Dao, Bonnie Thompson, Dana Dansereau, Rob McLaughlin, Janine Steele **Co-Creators:** Jeremy Mendes and Leanne Allison and the National Film Board of Canada	An interactive web based documentary experience based on footage and told from the perspective a grizzly bear in the Banff National Park. In March, 2017 *Bear 71* was re-released as a VR work viewable with Google Cardboard™ and Google Daydream™ HMD's (Anonymous 2017)
Mine Explorer **2015** **Format:** Interactive PC based VR	**Concept:** NISV and The Virtual Dutchmen Partners: the development of Mine Explorer was co-funded by CLICKNL and Jaar van de Mijnen 2015 (M2015). **Credits**: voice-over texts: written by Jesse de Vos. Archive research: Kelly Mostert, Jesse de Vos and Harry van Biessum. Voice-over recorded by Job de Haas, with voice actor Rufus Hegeman. Videos have been produced by Kelly Mostert with additional help from Lotte Belice Baltussen. The development of *Mine Explorer* was co-funded by CLICKNL and Jaar van de Mijnen (NISV 2015b).	A VR based project that takes a viewer on a virtual tour through the Dutch State Mines which have been closed for the last 50 years. The virtual space is interspersed with actual historical footage of the mines made available by NISN (The Virtual Dutchmen; NISV Labs).
***Big Art Ride* - the European Tour** **2016** **Format:** interactive VR	**Creators:** **Initiative and concept:** DROPSTUFF.nl **Project partners:** Europeana, NISV **Partners:** The Embassies of the Kingdom of the Netherlands in London, Berlin, Paris, Brussels, Rome, Warsaw, Prague and Vienna, Ministry of Education, Culture and Science and ING Bank Belgium	It was the aim of the *Big Art Ride* to connect participants all over Europe. Two trailers were set up in geographically separate locations in Europe. Each trailer contained a stationary cycling bike, Light Emitting Diode (LED) screens, VR HMD and camera/screen installation for live transfer. The participants (miles apart) could engage in a real bike race seeing imagery of European artworks within a virtual city. Audience members participated rallying the bike riders with interactive bicycle pump and bell and bike riders DROPSTUFF.nl).
Title: n/a collection of 360-degree video **Format:** 360 degree video installation	**Artist:** Hans Jaap Melissen	A collection of 360 degree video, by journalist Hans Jaap Melissen found on the YouTube channel: Brandpunt. As a result of Melissen's commissioned 360-degree video in 'News and Nonsense' (opening November 2017) a pilot program was initiated by NISV to archive Melissen's content (Brandpunt)

4. Preservation challenges and strategies

4.1 Designated communities and significant properties

Defining the most significant properties of an interactive work/piece provides a means to measure any future, unwanted change. This is a challenging task for immersive, expansive platforms that tend to defy the linear boundaries of traditional moving image formats. Given VR's wide use and appeal, its user base is also similarly difficult to define. As a cultural heritage institution charged with the care of content and its re-use for future audio-visual productions and other purposes, NISV has determined four major user groups: academic researchers, media professionals, organisations invested in education and the general public as designated user communities.

Using these categories, de Vos suggested the general public rubric was apt for what he termed interactives (commercially distributed computer and video games) (2013). Given the interactive nature and accessibility of VR, the general public will also be considered as the main user group for this research. 360-degree video works however, have been used widely as tools for documentary style narrative and their future use could also be extended to academic research and potential media re-use. But, as Annemieke de Jong points out, 'the situation within which designated communities request and use material may change, both in terms of 'receiving' systems and the desired format and the metadata and the intended use of the material (2016, p.39).

4.2 Complex systems

VR systems are composed of what digital preservation expert David Rosenthal terms 'dynamic content'. Such a phrase, he suggests describes the many different file and data types that vary widely in complexity and function together (2015). The interdependent relationships between such files and their operational reliance on both software and hardware makes preservation of them particularly challenging (Lischer-Katz 2017). Furthermore, most vendors create unique, proprietary files making communication and functionality between VR systems difficult if not impossible (Vince 2004, p.91). Even a final, executable (playable) VR file is composed of variable data including video formats, 3D model formats and audio functioning together. This file is often stored with a suite of software and project files, as well as possible iterations making best archival practice an overwhelming task for the uninitiated. These issues are compounded by the rate at which developers are creating new functionality within their systems. If unsupported by a vendor, new file formats may replace the old inevitably creating obsolescence. A lack of interoperability also occurs across VR software and HMD's as most vendors track user input within their VR systems differently further complicating the task of selecting which software and hardware versions to archive (Campbell 2017 p.102).

Many VR file formats do not allow for technical metadata to be embedded within them, this implies that details such as dimension, scale and provenance metadata are not accessible in the file format (as it would be in moving image formats or photographs etc.) but would need to be stored separately (Lischer-Katz 2017, p.9). Managing and obtaining the new technical, descriptive and administrative metadata necessary to understand and maintain formats such as 360-degree video and (more so) VR will be a major challenge for cultural heritage institutions, unsure of the level and necessity of recording such detail. And, as de Jong suggests, this metadata, will only increase as new information is generated at each step in the preservation production cycle, as preservation outputs continuously undergo changes and adaptations supported by technical metadata and documentation (de Jong 2003, p.3).

4.3 Towards standardisation

The only real solution to archiving complex VR proprietary formats that are proliferating at a rapid rate, is standardisation through a sustainable, interoperable file format to ensure data is not lost to obsolescence (Lischer-Katz 2017, p.8). While vendors like Facebook (Oculus Rift™) have, in the past, been guarded about their proprietary software, in December 2016 they (and a host of other vendors) announced support for the open VR standard proposed by the Khronos group Inc. (Orland 2017). This standard, Khronos suggests will take the form of an open and royalty free 'Open XR' application for VR applications and devices. It is envisioned that this will enable applications to be portable to any VR system conforming to the standard, giving greater flexibility in VR re-installation and ultimately creating less risk of obsolescence (Orland 2017). While open source formats are not entirely immune to obsolescence (support for files types can be abandoned by the open source community), they are a major step closer to sustainable format sources for efficient future preservation.

4.4 Migration and Emulation

NISV defines migration as 'the activity by which an older digital file-format is transformed or transcoded into a newer file-format' (NISV Preservation White Paper). Migration has been a popular preservation strategy in memory institutions charged with the care of linear moving image formats. The, non-standardised 'dynamic content' of VR however, makes migration a difficult and time consuming method, which also opposes the mass digitisation efforts imbedded in archive workflows. Instead, VR and other interactive content is thought to be 'most legibly preserved' within the 'interdependent software environments in which they were created' (Rhizome 2016, p.8).

Emulation occurs through a virtual machine (VM) on a host computer that mimics the original software environment. Although emulators do not yet exist for the VR platforms currently on the market, there may fast become a need for them as models are superseded. Gaming enthusiast and Reddit user, 'The-King-of-Spain', demonstrated the preservation potential of emulation as a preservation strategy for VR using RetroArch (an existing emulator) to access and play Nintendo's VR Virtual Boy™ originally released in 1995 (Vincent 2016). While 'The-King-of-Spain', arguably improved the look and feel of Virtual Boy™ with a smartphone instead of the original bulky headset (that purportedly caused headaches and motion sickness), the characteristic red was transformed to black and white. In theory, emulation as a preservation strategy is in keeping with the preventive conservation dictum to 'not interfere' or modify the structure and or appearance of and artefact as it mimics an environment for an original digital artefact to be played. In practice, concern has been raised over its ability to authentically replicate such environments. As Rosenthal suggests, there are two types of fidelity to consider - execution fidelity, whether the emulation executes the program correctly, and experiential fidelity, how close a user's experience is to the original user's experience (2015b). While the unofficial emulated version of Virtual Boy™ as tested by 'The-King-of-Spain' appeared different from the original, without emulation, the game may have remained inaccessible.

Retrospectively identifying original software environments to enact an emulation strategy for every single digital asset lost to obsolescence has proven time consuming for cultural heritage institutions. In part, this is due to what Rhizome suggests is a 'describing before using' paradigm as not enough machine actionable metadata is generated to allow for the effective matching of execution environments to artefacts (Rhizome 2016, p.11). For this reason Rhizome has begun to develop 'an open source software tool and dataset that will automatically connect collections of digital artefacts (including software) with emulation environments for re-enactment of the collection's contents. This would shift the focus of emulation from single objects into mass preservation, which would present a welcome change in archive practice.

4.5 Documentation

Archiving information such as images, instruction manuals, condition reports, descriptive texts, provenance articles and technical metadata can serve to support the understanding of an artefact or act as a representational substitute for it. It is an invaluable preservation strategy but determining the type and level of documentation to store for future use can be difficult. Documentation can have many varied purposes - for publicity and publication, reconstruction or preservation, describing processual changes, provenance and for recording the experiential elements of an artefact (Dekker 2012, p.152). Time-based media documentation strategies such as format specific templates used to record a singular artefact's condition, work defining properties and the artist's intent (or sanction)[2] have proven useful to capture and measure unwanted change but are also resource intensive. A combination of strategies that balance standardised documentation as well as those open to experimentation, responding to the singular artefact will prove most useful in preserving VR and 360-degree video. As the technology evolves and becomes even more immersive, documentation strategies will also need to evolve to record the experiential in and authentic manner either a-priori or a-posteriori, depending on acquisition approaches and content.

An effective a-posteriori documentary strategy was demonstrated in the 'Let's Play' project at NISV (Glas et al. 2017, pp. 139-142). Participants were invited to play Dutch interactive video games from the 1980's within NISV and agreed to have their interactions video-recorded to capture the experiential aspect of play. While these recordings were not made during the initial creation or acquisition of the game (a-priori), the recordings made in 2016, captured dialogue between players that delivered a comparative analysis between old and new interactive games. Contextualising the old, provided the beginning of a documentary style history of experiences. Another a-posteriori method was conducted in the 'Play it Again' project in Australia and New Zealand. Participants in this project (the general public) were asked to contribute memories, thoughts or images of themselves playing Australian or New Zealand video and interactive games, which were uploaded to the project's website. This archive initiated a social memory documentation deposit and also invested in the software and hardware preservation of the games (Play it Again 2015).

The level of contribution from the general public (evident in the Play it Again archive) and gaming community's desire to access obsolescent computer and video games as seen with Virtual Boy™, is testament to their collective skill base and ability to sidestep the proprietary formats, often publishing their methods on open source platforms. The collective knowledge of the gaming community may serve as an excellent resource in seeking tools for preservation (while maintaining a level of caution that respects a creator's copyright).

[2] Conservator and Clinical Associate Professor in Museum Studies at New York University, Glenn Wharton considers using philosopher Sherri Irvin's "implicit sanctions" or "tacit assumptions" instead of artist intent for a better 'understanding of the complex relationships between ideas in artists' minds, diverse influences on their work, and the art that they create' (Wharton 2015, p.10).

4.6 Stepped approach to preservation

Without standardised file formats, a staged preservation approach for VR appears to be the most viable option currently available. In the NISV 'Digital Preservation Sound and Vision: Policy, Standards and Procedures' a bit preservation or passive preservation approach entails storing files as they are received, without analysis and therefore no guaranteed for short or long-term accessibility (de Jong 2016). This level of preservation is currently afforded to *Mine Explorer*, 2015 which is located on a local hard drive at NISV (as well as a copy of an executable file of the piece currently playable at the Mine Museum, Heerlem).

If and when a preservable format is available, full or active preservation may be explored to keep a file or format usable/playable. For *Mine Explore*r this may imply the use of emulators and or file migration if a standardised format becomes available (however unlikely that may seem now). This method too poses risks. In waiting to decide what VR and 360-degree video to collect as exemplars (*Mine Explorer* is not officially apart of the collection), current examples may become obsolescent or lost. Yet, if institutions collect an array of new technology before they are ready to preserve in a proactive manner, loss of files and the integrity of the work may be compromised. This may prove highly costly and labour intensive to retrieve or reconstruct at a later date.

5. 360-degree video

Unlike VR, the preservation of 360-degree video (with the exception of projection maps) should be similar to that of other linear moving image formats. A suite of small cameras (within one device) and software create 360-degree videos by stitching together many flat videos/images, combined to form a panoramic, spherical shape and image. This process can be captured and stored or live streamed directly to online platforms like YouTube. In either case the resultant file formats are: mov. avi. mkv. and mp4 and spherical video content can be encoded in MPEG-4 in the standardised h.264 or h.265 codecs (Campbell 2017, pp. 63-66).

To test the archiving process of 360-degree video, NISV initiated a pilot program with journalist Hans Jaap Melissen (see Brandpunt for 360-degree video collection). As Melissen has contributed to the exhibition 'News and Nonsense' which opened at NISV in November 2017 it was an opportune time to ask him about his practice. Most of his 360-degree videos have been created using Samsung gear 360 cameras and outputted to h.265 files (although earlier trials were developed with GoPro cameras and varied output formats). The next step in a preservation plan to archive these videos would be to obtain the h.265 files. Either the artist (who is invested in the archiving process) could deliver such files to NISV or alternatively, as they are already uploaded to YouTube in the same format, they could be assimilated into the pre established web-based archiving practices at NISV. In either case, rights to reuse the content in the archive setting would need to be formalised with the artist.

When asked about the idea of the potential re-use of 360-degree video in the future, in a similar manner in which linear moving image is repurposed in broadcasting and other applications Melissen thought that is would be likely and possible. Simple techniques such as using a fade between segments would counteract the discombobulating effect felt by scene cuts; a common device used in linear narrative in 2D formats (H. J. Melissen pers. comm October 5, 2017). This points to an on-going use for 360-degree content for archives and the designated communities previously described, especially at the beginning of the development of such new technology.

A documentation strategy to preservation such as that used in the practice of time-based media (TBM) conservation, might also consider embedding a process to formally interview producers, artist creators like Melissen.

6. Further research and results

There is much research and practical experimentation to be done for VR preservation. Potential areas not explored in this paper could include:

- Selection criteria for potential VR and 360-degree works, what exemplars of VR and 360-degree video (as well as AR and MR) should NISV collect to best represent the technology and content being created?
- A survey of institutions collecting and or archiving VR and 360-degree video in the Netherlands. A distributed network of knowledge, research and specific collecting goals would enable the sharing of resources, for instance, not every institution needs to collect both hardware and software for every VR platform
- Trend watch on VR and 360-degree video standardisation terminology and formats as well as new technology to predict potential areas for collecting and integrating into a white paper document
- A cross discipline pilot collaboration for VR with makers already (for instance Dropstuff n.l who created the Big Art Ride and the Virtual Dutchmen) a-priori documentation strategy might consider the process of collecting before distribution, or documenting the experience of interactivity upon release of VR content at the beginning of a project
- A comprehensive study of designated communities and use for VR and 360-degree video
- Legal implications of using and storing emulators as well as on-going costs for both
- The staff resources and financial implications for a pilot program and on-going facilitation of VR and 360-degree preservation
- Metadata schema to capture technical metadata for VR

7. Conclusion

A number of institutions were contacted during this project to enquire about internal preservation practices for these formats including: The New Institute (Rotterdam), The Royal Library: Det Kongelige Bibliotek (Copenhagen), Institut national de l'audiovisuel INA (France) and ACMI. All institutions were interested in archiving VR content or already had some in their collection. Due to uncertainty around how best to preserve VR however, preservation plans had not yet been implemented or explored in detail.

While it appears that 360-degree video can be assimilated into the pre-established preservation practice through web archiving protocols at NISV, VR cannot. The file complexity, interactive and immersive qualities to VR make it far more difficult to archive effectively. Without standardisation of file formats, VR cannot assimilate into current NISV preservation workflows and will either require a time-based media conservation approach using a case by case evaluation or a staged, bit preservation strategy. Preservation strategies such as migration may still be suitable for 360-degree video but far too time consuming and ineffective for VR content. A bit or passive preservation approach followed by emulation and full preservation may better suit the complexities of interactive VR and the institution's workflows.

A collaborative approach in a pilot project and white paper document would be ideally suited to this new domain of preservation and could encourage national and international interest and collaboration. Sharing and collaborating across a distributed network of collections and institutions could also serve as another preservation strategy that sees institutions focusing on separate but connected areas, making best use of resources. New technology brings with it new challenges in documenting and archiving metaphysical aspects like interactivity and the experience of immersion as well as the projected designated users and their future access needs.

8. References

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