Preservation Guide: DVD-R

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Abstract

The archiving and preservation of digital media is of increasing concern given the wide variety of digital media storage formats created from the latter half of the 20th century to today (Leggett, 2012; Brown, 2013). The overall aim of this guide is to define the preservation of content stored on optical disc (OD) media in general, with a focus on Digital Versatile Discs-Readable (DVD-R). The first section, *Context,* outlines the specifications of and challenges to the preservation of OD media. The second section, *Recommended Accession Strategy,* is a general process for digital migration and archival ingestion of the content stored on these discs based on a survey of best practices in the literature. The third and final section outlines two workflows: one for discs created for archival purposes and one for discs not created for archival purposes. Appendices 1 and 2 are step by step user guides recommended for each workflow. This guide has been tailored to the University of Ottawa Archives (ARCS) and is by no means comprehensive.

Section I. Context

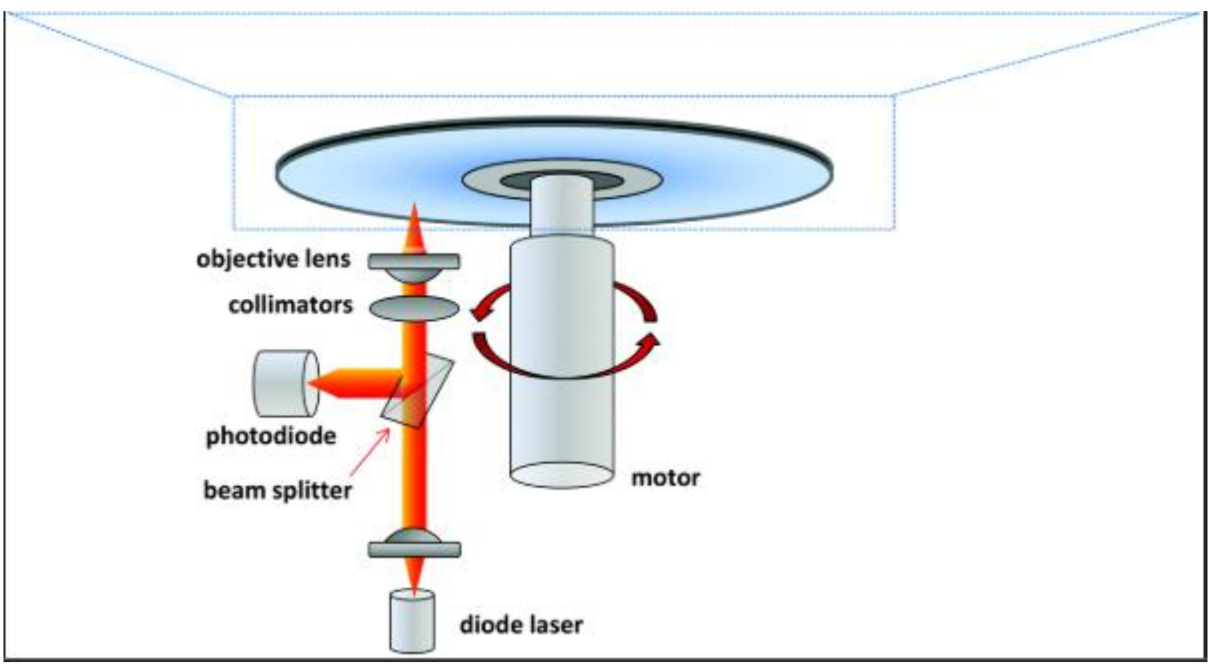
Optical Disc (OD) Media

Optical discs (OD) carry digital information in the form of computer files and/or programs (Schweikert, 2018). They consist of compact discs (CDs), Digital Versatile Discs (DVDs) and many other formats. Optical discs are common in an archival setting, especially in collections dating from the latter half of the 20th century ([PSAP], n.d.). Table 1 includes a list of the most common types, storage capacities and approximate dates of use (Wikipedia "Optical disc", n.d.).

Optical Disc (Wikipedia)

The data on optical discs is stored in pits arranged in a spiral pattern, which are physically burned into the disc and read by a laser as the disc rapidly spins inside a reader as shown in Figure 1. For more on how to read an optical disc, see the *Hardware* section of this guide.

Figure 1 Optical Disc Reader (Weng, 2016)



Digital Versatile Discs-Readable (DVD-R)

Specifications and Common Uses

Digital Versatile Discs (DVDs) are considered “second-generation optical discs”, the first generation being CDs (Schweikert, 2018; Wikipedia "Optical disc", n.d.). Second generation ODs can store larger amounts of data than their predecessors and were specifically designed for high-quality video. However, they are also commonly used to store high-quality images and other large files (Schweikert, 2018). DVDs are read with a visible-light laser, usually in the red colour spectrum, which reads the pits in the disc and translates them using computer software as shown in Figures 1 and 2. The standard DVD can hold a minimum of 4.7 gigabytes (GB) of data storage on a 12 cm, single-sided disc (Wikipedia "Optical disc", n.d.). There are several types of DVD as shown in Table 2. DVD-R are readable only and cannot be written over or “burned” again (Schweikert, 2018; Forde & Rhys-Lewis, 2013).

Hardware

Optical Disc in Reader Tray (PSAP)

The Optical Storage Technology Association (OSTA) recommends that users look for products which display the “MultiRead” or “MultiPlay” logos or consult with the hardware manufacturer if unsure ([OSTA], 2004). The University of Illinois Preservation Self-Assessment Program (PSAP) recommends that archivists do not use rare or unique optical discs in unknown hardware. Instead, best practice is to insert a test or “dummy” disc into the drive to ensure the reader does not damage it ([PSAP], n.d.).

Most DVDs can be read on any 12 cm standard size CD-ROM reader or commercially available DVD player ([OSTA], 2004). Discs should be inserted into the reader drawer so that they lie flat in the tray, holding the disc by the outer edges and interior opening to avoid touching the readable surface. Single-sided discs should be placed in the reader so that the shinier, readable side faces downward. If a disc is double-sided, or readable on both sides, it can be placed in the reader in either orientation.

Challenges to Preservation and Best Practices

The Canadian Conservation Institute (CCI) has identified “Nine Agents of Deterioration” that affect the long term preservation of physical collections as shown below in Table 3 (Michalski, 2004). These factors should be addressed as the baseline of any preservation strategy for physical collections, including optical discs (OD). There are however additional considerations that apply specifically to OD media as identified by the literature: obsolescence, storage conditions and physical damage ([PSAP], n.d.; Iraci, 2012; Forde & Rhys-Lewis, 2013).

Table 3 *"The Nine Agents of Deterioration"* (Michalski, 2004)

Table 1. The Nine Agents of Deterioration

Agent of Deterioration	Risks of the Agent (Form of loss or damage, and the vulnerable collections)	Hazards (Sources and Attractants of the Agent) Partial list	Some other activities and disciplines involved in management of each risk
Direct physical forces e.g., shock, vibration, abrasion, and gravity	Breakage, distortion, puncture, dents, scratches, abrasion. All artefacts.	Earthquakes. War. Poor handling. Overcrowded storage. Transit inside and outside the museum.	Conservation.* All museum staff for detection, handling, and for emergency response. Building cleaning services. Emergency preparedness, museum and government.
Thieves, vandals, displacers i.e. unauthorized human access and removal. 1 Intentional 2 Unintentional	1 Total loss, unless recovered. All artefacts, but especially valuable, and portable artefacts. Disfigurement, especially of popular or symbolic artefacts. 2 Loss or misplacement. All artefacts.	Professional and amateur criminals. General public. Museum staff. Highly visible precious artefacts.	Security. Collection management. Curators and researchers. Local police.
Fire	Total destruction with no recovery. Scorching. Smoke damage. Collateral water damage. All artefacts.	Exhibition installation. Faulty electrical, lighting systems. Arson. Careless smoking. Adjacent buildings.	Security (fire). All museum staff for detection. Local fire service. Conservation*
Water	Efflorescence or tide marks in porous materials. Swelling of organic materials. Corrosion of metals. Dissolution of glue. Delamination, tenting, buckling of artefacts with layered components. Loosening, fracture, corrosion of artefacts with joined components. Shrinkage of tightly woven textiles or canvases.	Floods. Storms. Faulty roofs. Internal faulty water and sewage connections. External faulty water and sewage connections. Wet pipe fire suppression systems.	Conservation.* Emergency preparedness, museum and government. All museum staff for detection, and for emergency response. Building cleaning services.
Pests 1 Insects 2 Vermin, birds, other animals 3 Mould, bacteria (see Incorrect Relative Humidity: damp)	1 Consumption, perforation, cuts, tunnels. Excreta that destroys, weakens, disfigures, or etches materials, especially furs, feathers, skins, insect collections, textiles, paper, and wood. 2 Consumption of organic materials, displacement of smaller items. Fouling with faeces and urine. Perforation, fouling of inorganic materials if they present an obstacle to reaching the organic material.	Surrounding landscape. Vegetation habitats near building perimeter. Garbage habitats. Incoming building materials. Incoming artefacts. Incoming staff, visitors. Spilled foods.	Conservation.* Building operations. Food services. Exhibit design. All museum staff. External pest control companies. External biologists for identification.

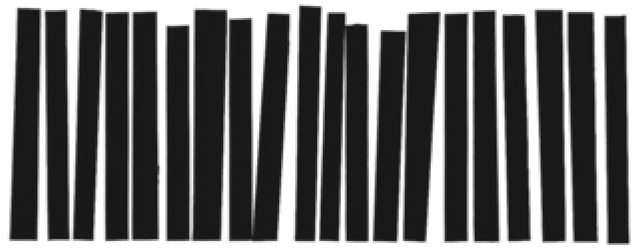
Obsolescence

The greatest challenge to the preservation of any digital media is obsolescence. Digital media technology updates rapidly and institutions such as archives do not always have the correct hardware or software to read and preserve it ([PSAP], n.d.). Preservation of the physical carrier of digital media is an interim strategy, as all media carriers have finite lifespans (Iraci, 2012; Brown, 2013). While physical preservation does extend the lifespan of digital media, a longer-term strategy for preservation is transfer and ingestion to a trusted digital repository

(Duryee, 2014; Schweikert, 2018). This process will be outlined in the second section of this guide.

Storage

The PSAP recommends that optical discs be stored in a vertical orientation on shelves or in drawers as when storing books ([PSAP], n.d.). Besides their orientation, the quality of the environment in which the optical discs are stored is essential to long-term preservation, which will be discussed in the following sections of this guide.



Optical Disc Storage Orientation (PSAP)

Relative Humidity

Relative humidity should be kept under 65% to inhibit mould growth in all physical collections, which is discussed further in the *Mould* section of this guide (Michalski, 2004). Methods for controlling humidity are ideally worked into the design of an archival building, but humidity can also be lowered in the short term with commercially available dehumidifiers (Forde & Rhys-Lewis, 2013).

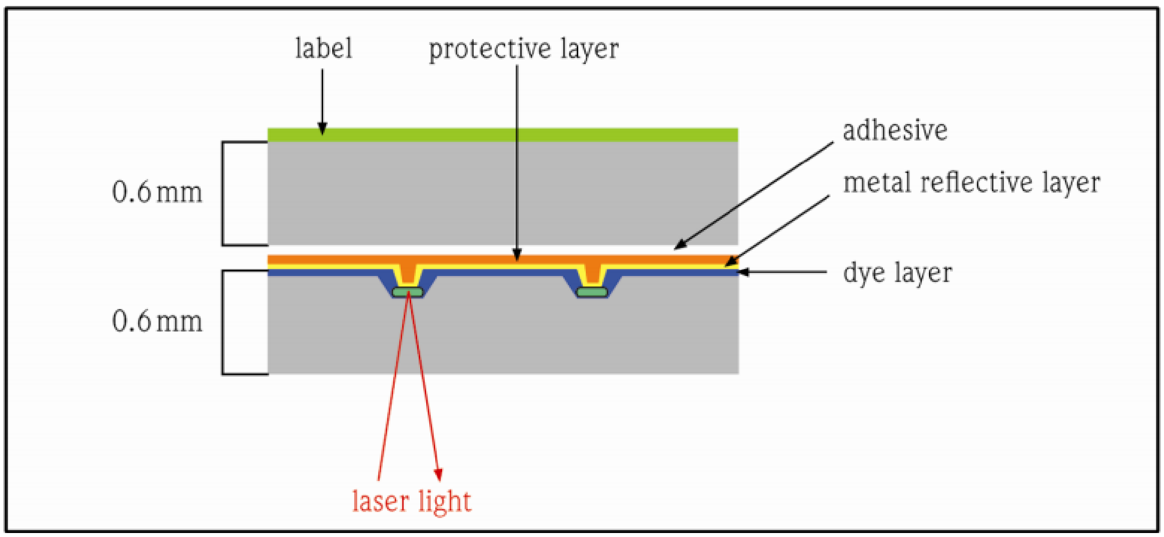
Temperature

Stable temperature conditions are ideal for the long-term preservation of any archival collections (Forde & Rhys-Lewis, 2013). However, optical discs are particularly sensitive to heat, which accelerates their deterioration. While there is currently no evidence that exposure to cold temperatures has any effect on optical discs, a stable storage temperature in a relatively cool environment is considered best practice (Iraci, 2012; [PSAP], n.d.).

Light Levels

Like temperature, light levels in physical collections should be kept relatively low and stable over time (Michalski, 2004). Ultraviolet (UV) light from the sun is the most damaging type and should be avoided. Florescent lights emit much lower levels of UV light and are safer for any collection. The main risk of UV light exposure to optical discs is to the dye layer, which if degraded, can render the disc unreadable as shown in Figure 2 ([PSAP], n.d.; Iraci, 2012; Forde & Rhys-Lewis, 2013).

Figure 2 "A cross-section of a recordable DVD" (Iraci, 2012)



Appropriate Containers

Research on optical disc storage long-term is currently inconclusive, but studies indicate that optical discs should be stored individually in “jewel cases”. Jewel cases are plastic containers specifically designed to hold discs securely. Optical discs may be stored in paper envelopes, or in stacks over a central hub temporarily, but this should be avoided long-term (Iraci, 2012; [PSAP], n.d.).

Empty Jewel Cases (PSAP)

Physical Damage

Scratched Optical Disc (PSAP)

Scratches/Fingerprints

Scratches or fingerprints on the readable side of an optical disc may render it fully or partially unreadable in a laser reader (Figs. 1 and 2). This type of damage can be prevented by careful handling and storage of optical discs ([PSAP], n.d.). For more on how to handle discs when reading, see the *Hardware* section of this guide.

Mould

Mould spores of any type are of immediate concern to physical collections as they can damage large amounts of material irreversibly. These spores are also a serious health concern and should be dealt with immediately upon suspicion. Mould can present in a variety of colours and textures but is usually most noticeable by its distinctive odour. Outbreaks of mould can be prevented by maintaining appropriate storage conditions, especially relative humidity (Forde & Rhys-Lewis, 2013; Michalski, 2004; [PSAP], n.d.)

Mould on an Optical Disc (PSAP)

Pests

Like mould, pests are best prevented, rather than dealt with after the fact. Insects and rodents thrive in warm, moist conditions, therefore controlling temperature and relative humidity is essential. It is more likely to encounter the evidence of a pest infestation than to see the pest itself. For example, a mouse will leave behind droppings (as shown to the left with a penny for reference). If pests are detected in any collection, extermination procedures should be enacted immediately (Forde & Rhys-Lewis, 2013; [PSAP], n.d.).

Evidence of Pests (PSAP)

Disc Rot

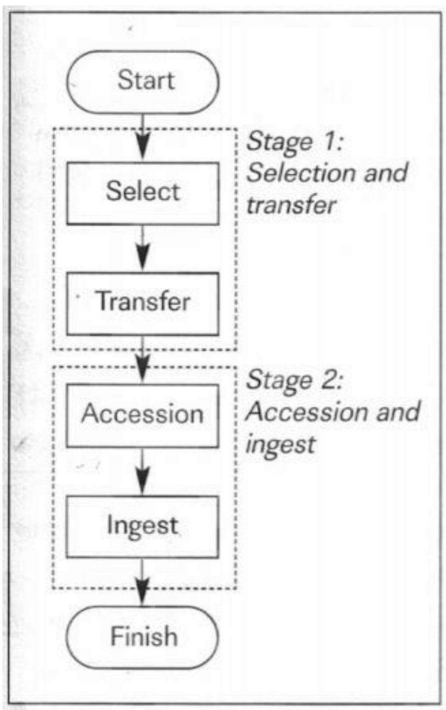
“Disc rot” also known as “laser rot” is a phenomenon that occurs when the aluminum layer of the optical disc oxidizes and deteriorates (Fig. 2). It can cause partial or complete loss of the information recorded on the disc. It presents as small holes, usually around the outer edges of the disc and can be confirmed by holding the disc up to a light. Disc rot cannot be prevented or reversed, and all optical discs will deteriorate over time. However, it can be mitigated by controlling relative humidity and temperature in storage ([PSAP], n.d.).

Example of Disc Rot (PSAP)

Section II. Recommended Accession Strategy

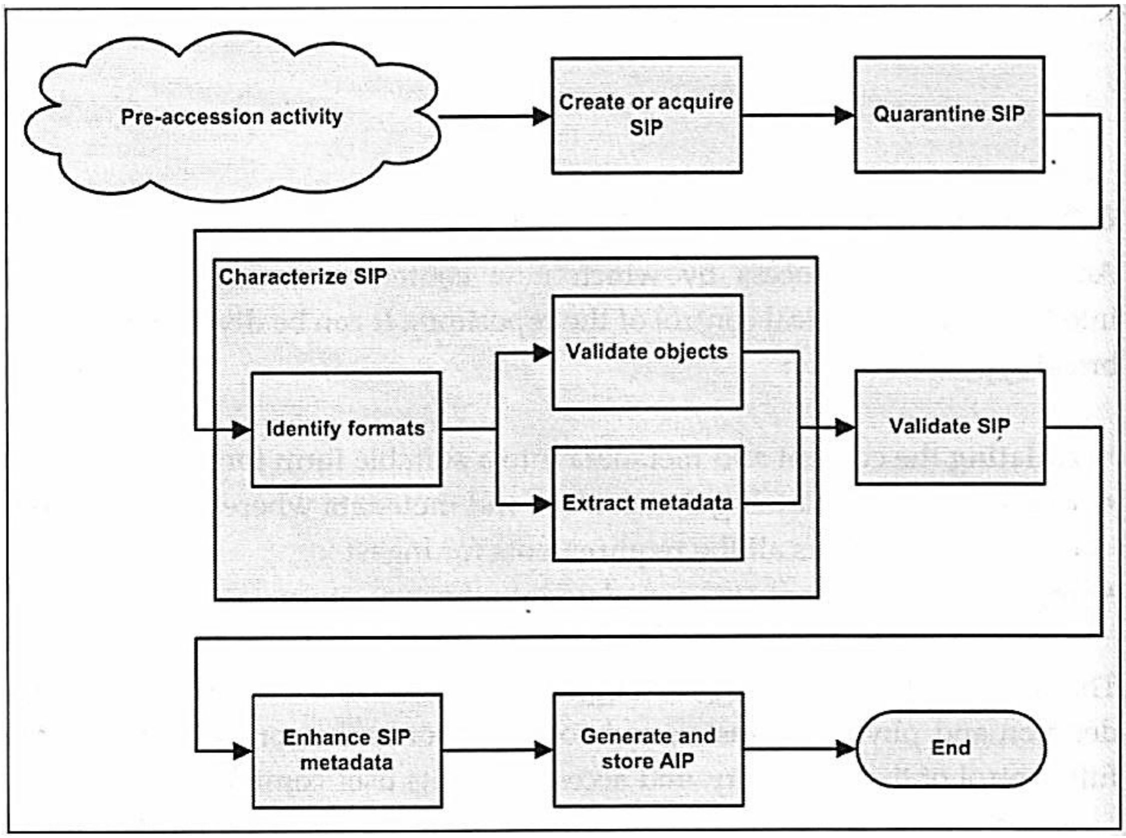
Accession refers to the process of ingesting a work into an archive. While this will look different at each institution, the overarching steps are outlined in the workflow shown below in Figure 3 (Brown, 2013).

Figure 3 "Stages of acquiring digital objects: selection to ingest" (Brown, 2013)



Optical discs including DVD-R are prone to degradation over time and are continually at risk from various environmental factors as outlined in the first section of this guide. As such, they are not preferable for long-term preservation of digital media. Therefore, the recommended strategy for long-term preservation of digital content on optical discs is migration to a secure digital repository and destruction of the original disc as shown in Figure 4 (Leggett, 2012; Forde & Rhys-Lewis, 2013; Brown, 2013; Duryee, 2014; [PSAP], n.d.; Schweikert, 2018). For the purposes of this guide, activities will be outlined up to the step, *Enhance SIP Metadata*.

Figure 4 "Model accession workflow for digital objects" (Brown, 2013)



The Accession Process

The accession process includes the creation of three information packages:

1) Submission Information Package (SIP)

2) Archival Information Package (AIP)

3) Dissemination Information Package (DIP)

(Digital Preservation Coalition, n.d.; Brown, 2013)

Though the SIP creation process will be largely automated by software, it is important to understand it conceptually in order to correct for any errors or omissions manually.

ARCS is a member of the Ontario Council of University Libraries (OCUL), which offers a subscription to "Archivematica". Once a SIP is created, it is then uploaded through Archivematica, which generates the next information package, the AIP (not covered in this guide). These are both stored in the Ontario Library Research Cloud (OLRC), which is a trusted digital repository (Archivematica, n.d.).

1. Pre-Accession

This guide assumes that the initial decision to ingest the material in question has already been made in the affirmative and that ARCS has the legal and intellectual property rights to proceed with the transfer stage of ingestion as show in Figure 4 (Brown, 2013). Considerations for transfer prior to ingestion will be the focus of this section.

Virus Scanning

Any content to be transferred from optical discs must be scanned for digital infections such as viruses and malware (Brown, 2013). For specific instructions on how to conduct a virus scan, see the third section of this guide.

Damage

Optical discs may show signs of deterioration or damage as outlined in the previous section of this guide. If discs are damaged, preservation specialists may be able to repair them, but this is not guaranteed (Brown, 2013). Discs that are free of damage should be prioritized for transfer as they will have the highest likelihood of success (Michalski, 2004; [PSAP], n.d.).

Documentation

The documentation required here consists of the provenance, or origin, of the digital object and/or the original document from which it was produced. It can also include donation information, such as a description/photo of the object, donor name, time, place and location of donation and the value of the object (Brown, 2013).

Size of Data

The overall digital storage space that the artefact occupies is an important consideration pre-ingestion in order to ensure that there is sufficient storage space in the institution's digital repository. This is usually measured in gigabytes (GB). Unusually large amounts of data may not be suitable for transfer until additional storage is available (Brown, 2013).

2. Create or Acquire SIP

A Submission Information Package (SIP) is the first of the three information packages outlined in the Open Archival Information System (OAIS) Reference Model (DLM Archival Standards Board, 2019). The SIP should be considered as a concept framing various outputs rather than an output itself. Although there are many forms a SIP can take, it should contain four basic elements:

1) descriptive metadata of the content;
2) descriptive metadata of the package;
3) technical metadata of the package; and
4) packaging information describing the layout of the package (Brown, 2013; DLM Archival Standards Board, 2019).

3. Quarantine SIP

Although the SIP will have been scanned for digital infections pre-transfer, another important step is to quarantine a SIP for long enough that virus and malware definitions can be updated before ingestion. The minimum suggested timeframe for quarantine is 30 days. If malicious software or viruses are found in the SIP, a decision must be made on whether to attempt to remove the infection or stop the accession process (Brown, 2013).

4. Characterize SIP

Identify File Formats

If there remain any unidentified or unreadable file formats contained on the optical disc, they must be positively identified and migrated to more recent file formats. Files may be identifiable by their file extension, i.e. ".pdf" for a PDF file, but it may also be necessary to examine the bitstream itself (Brown, 2013). If file formats are difficult to identify, software can do this automatically as discussed in section III of this guide.

Validate Objects

Validation refers to the process of checking whether files are intact and readable by current software. This early detection can help avoid degradation of files in the future. If validation problems exist, a file may be accepted with a note on the issue (Brown, 2013). This process is most easily accomplished by using the "checksum" function in the software in use (BitCurator, n.d.).

Extract Metadata

Metadata for digital items can be thought of in two broad categories: descriptive and technical. Descriptive metadata relates to the context of the object, such as its history and author while technical metadata, as its name suggests, outlines the technical specifications of a digital object (Brown, 2013).

Descriptive Metadata

There are many descriptive metadata cataloguing standards currently in use that have been developed to describe physical objects. ARCS uses primarily Dublin Core (DC) standards for descriptive metadata. Therefore, the full set of "Dublin Core Elements" should be captured prior to ingestion:

- Title
- Creator
- Subject
- Description
- Publisher
- Contributor
- Date
- Type
- Format
- Identifier
- Source
- Language
- Relation
- Coverage
- Rights

(Brown, 2013)

Technical Metadata

Technical metadata for the digital objects stored on optical discs will be extracted by software in the Preservation Metadata: Implementation Strategies (known as PREMIS) format which has five "entities", listed below:

- Intellectual Entity: the work in context, such as title, author, other descriptive metadata.
- Object: the digital object itself, which has three elements:
  - File: digital material in a particular format
  - Bitstream: embedded data in a particular sequence
  - Representation: a set of digital material that forms an intellectual entity
- Event: an action taken
- Agent: a person, organization or system
- Rights: legal rights or permissions

(Brown, 2013)

5. **Validate SIP:**

This step is in the form of a self-evaluation. The archivist(s) compiling a SIP should ask is the SIP is:

- Complete - Does the SIP contain all relevant information about the object to be accessioned?
- Accurate - Is all metadata contained in the SIP correct?
- Formatted Correctly - Do all components of the SIP conform to accepted formats for ingestion?
- Intact: Perform Checksum- Has there been any degradation or loss of data during transfer? This can be verified using the “checksum” function (BitCurator, n.d.; Brown, 2013).

6. **Enhance SIP Metadata**

The final phase in preparing a SIP is to document the process itself. Metadata will be created at each step in the process, therefore keep this in mind and record pertinent details throughout the process. Besides the date and time of each step, software and methods used should be recorded for future reference should the process need to be recreated in future (Brown, 2013; DLM Archival Standards Board, 2019).

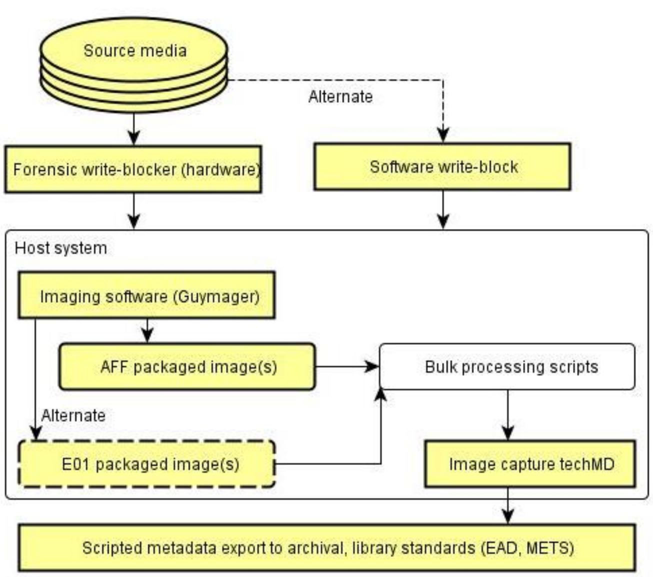
Section III: Proposed Workflows

1. **DVD-Rs Not Created for Archival Purposes: BitCurator**

DVD-Rs not created intentionally for archival purposes may arrive as part of a fond that contains media used for temporary storage. These discs can contain personal identifiable information (PII), viruses or malware and must be treat with caution. Therefore, all the accession steps in Section II must be followed in addition to the creation of a forensic disc image and a scan for PII. The best software currently available for this task is BitCurator: https://bitcurator.net/. This process is quite lengthy and could take up to several days depending on how large the files to be transferred are.

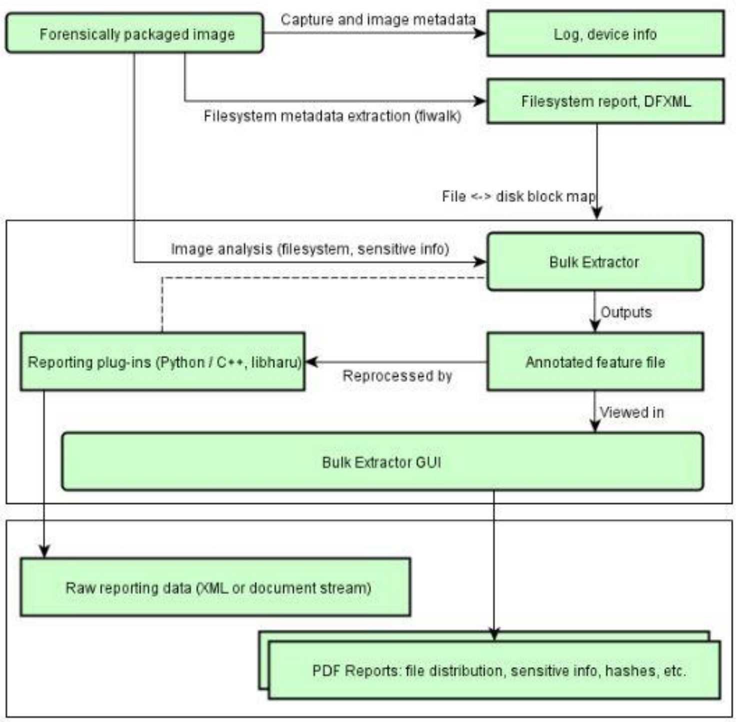
BitCurator runs best in a Linux environment and it is recommended to keep the computer running BitCurator isolated from other systems, so that viruses or malware can be contained should they infect it (Caldwell, 2018). The first step in processing a disc with unknown contents is to create a forensic disc image that will remain uncorrupted should any damage to the disc occur during the accession process. This workflow is show below in Figure 5.

Figure 5 "BitCurator imaging procedure" (Confluence, 2018)



Another important step in accessioning discs of this type is to identify any personal identifiable information (PII) such as addresses, phone numbers, email addresses, or any other personal information. The workflow for identifying PII is shown below in Figure 6.

Figure 6 "BitCurator Potentially Sensitive Information/PII identification" (Confluence, 2018)



For detailed step by step instructions on how to accession discs of unknown content or origin using BitCurator, see the report *Accessioning Born-Digital Content with BitCurator* by John Caldwell attached here as an appendix (Caldwell, 2018).

2. DVD-Rs Created for Archival Purposes: Exactly

DVD-Rs that have been created specifically for archival purposes can be treated with much less caution, since their contents and origin are usually known. These types of discs include copies of hard copy media transferred to digital form, such as books, images, videos, etc. The best tool currently available for discs of this type is Exactly by AVP: https://www.weareavp.com/products/exactly/. This process is much shorter and less involved than using BitCurator and it is a preferable choice when accessioning many archival DVD-Rs of known content.

Exactly can run on any computer connected to the internet using a Microsoft or iOS or Java (Jar) operating system. The University of Kentucky produced an excellent step by step user guide for accessioning media using Exactly that is attached here as an appendix (University of Kentucky Libraries Louie B. Nunn Center for Oral History, 2016).

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Tables

Table 1: "Overview of Optical Types" (Wikipedia "Optical disc", n.d.)

Name	**Capacity**	**Years in Use**
LaserDisc (LD)	0.3 GB	1971–2001
Write Once Read Many Disk (WORM)	0.2–6.0 GB	1979–1984
Compact Disc (CD)	0.7–0.9 GB	1982–present
Electron Trapping Optical Memory (ETOM)	6.0–12.0 GB	1987–1996
MiniDisc (MD)	0.14 GB	1989–today
Magneto Optical Disc (MOD)	0.1–16.7 GB	1990–present
Digital Versatile Disc (DVD)	4.7–17 GB	1995–present
LIMDOW (Laser Intensity Modulation Direct OverWrite)	2.6 GB	1996–present
GD-ROM	1.2 GB	1997–present
Fluorescent Multilayer Disc	Not available	1998-2003
Versatile Multilayer Disc (VMD)	5–20 GB	1999-2010
Hyper CD-ROM	1 PB	1999?-?
Ultra Density Optical (UDO)	30–60 GB	2000-present
FVD (FVD)	5.4–15 GB	2001-present
Enhanced Versatile Disc (EVD)	DVD	2002-2004
HD DVD	15–51 GB	2002-2008
Blu-ray Disc (BD)	25 GB 50 GB 100GB (BDXL) 128 GB (BDXL)	2002-present
Professional Disc for Data (PDD)	23 GB	2003-2006
Professional Disc	23–128 GB	2003–present

Digital Multilayer Disk	Not available	2004–2007
Multiplexed Optical Data Storage (MODS-Disc)	Not available	2004–present
Universal Media Disc (UMD)	0.9–1.8 GB	2004–2014
Holographic Versatile Disc (HVD)	Not available	2004–present
Protein-coated Disc (PCD)	Not available	2005–present
M-DISC	4.7 GB (DVD format) 25 GB (Blu-ray format) 50 GB (Blu-ray format) 100 GB (BDXL format)	2009–present
Archival Disc	0.3-1 TB	2014–present
Ultra HD Blu-ray	50 GB 66 GB 100 GB	2015–present

Table 2: *Types of DVD* (Schweikert, 2018)

DVD Type	**Year First Produced**	**Description**
DVD-R	1997	recordable discs to carry data or video
DVD-ROM	1997	(ROM=Read Only Memory), typically used to carry software and games
DVD-RAM	1997	rewritable discs (RAM=Random Access Memory)
DVD-RW	1999	rewritable discs to carry data or video
DVD+RW	2001	rewritable discs to carry data or video
DVD+R	2002	recordable discs to carry data or video