The Current State of Photochemical Film Preservation:

A Closer Look at Motion-Picture Film Stocks and Film Laboratories

by

Shahed Dowlatshahi

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Introduction

Memory institutions such as archives, libraries, and museums across the globe care for a vast array of culturally and historically significant items composed of moving images: historical news footage, feature-length studio films, home movies, and countless other types of film and video. Many of these items are on film, whether nitrate, acetate, or polyester. Having lasted since its birth in the late 19th century until today, film is the longest-running method of producing moving images; however, as moving image capture technology expanded with the introduction of videotape and born-digital files, the techniques and materials available to the moving image archiving and preservation field changed drastically and continue to evolve.

Moving images were shot and viewed on film strips prior to the advent of television; the introduction of television and later magnetic videotape initiated the alteration and diversification of moving image carriers. Before the 1990s, film preservation and restoration work was done almost exclusively through photochemical methods using film stocks and film laboratories equipped with film processing and printing equipment. As digital tools and technologies started being integrated into film post-production workflows in the 1990s and onwards, they started proving useful in the work of film preservation and restoration.

With the advent of digital technology, the traditional methods of film preservation and restoration were altered significantly. One of the first instances of the use of digital video technology in film preservation was a collaboration between Kodak and Disney to restore *Snow White and the Seven Dwarfs* (1937) in 1993. In this process, a pre-print film was scanned using Kodak's Cineon Digital Film Scanner and each frame was converted to a digital still image; the digital images were subsequently manipulated to remove imperfections through the use of specially designed software; and the resulting digital images were exposed back onto film using

Kodak's Cineon Digital Film Recorder. This project marked the first fully digital restoration of a big studio film.[1] While extremely expensive, this restoration also laid much of the ground-work for today's hybrid and digital methods of film preservation and restoration, including the standardization of the DPX file format, and the introduction of Kodak's Cineon film scanning and recording systems.[2]

Today, a variety of factors continue to alter the means and ends of film preservation as it was practiced since the earliest decades of the 20th century. Despite the fact that a sequence of 200,000 images printed on film and 200,000 digital images are different objects and media, digitization of film is now considered a viable film preservation method and has replaced photochemical duplication methods for many moving image archives worldwide. While digitization alters film's original medium, its benefits have played a significant role in its wide adoption. Digital files can be duplicated bit-for-bit, with no loss between generations–eliminating the quality loss between generations observed in film-to-film duplication. In addition, once film has been digitized, the cost of making duplicate digital files–multiple DCPs for cinema exhibition for example–is much lower than the cost of making multiple film copies; however, the cost of long-term storage and maintenance of multiple large digital files complicates the expense comparison. Despite the trend of film digitization replacing analog film duplication as the predominant method of ensuring the survival of film-born moving images, the practice of film-to-film preservation continues across the globe today and is by no means obsolete.

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[1] Giovanna Fossati, *From Grain to Pixel: The Archival Life of Film in Transition* (Amsterdam: Amsterdam University Press, 2009), 82.

[2] Glenn Kennel, "Digital Film Scanning and Recording: The Technology and Practice," *SMPTE Journal* 103, no. 3 (Mar. 1994): 174-181.

In the shifting landscape of moving image archiving and preservation, artists, archivists, curators, scholars, technology historians, film preservationists, and others in the field have continued to grapple with questions surrounding the digital transition for more than two decades. As the original film medium of an entire set of art works and archival holdings refuses to budge to total obsolescence, the ethical and practical questions of how to preserve these objects and present them to future generations are profound. Posing quandaries that remain unsolved is a common theme in writing on the subject. Artist and film preservationist Bill Brand, who served as an advisor to this research project, posed a multitude of these questions in 2012:

> Does a digital simulation of a film projection, even one that is nearly identical in appearance to an audience, fundamentally change the meaning of these works? Are these films best preserved by maximizing their availability for exhibition and distribution in digital formats, or does the transformation to digital render them existentially lost? Do widening opportunities for distribution and exhibition increase the market value potential of 16mm film prints by increasing awareness of the films' existence, or do they devalue it through an inverse law of scarcity? If the films' value is decreased, does that likewise diminish their chances of longterm survival, or do scarcity and consequent high value actually increase the chances of films being treated as precious objects worthy of long-term care?[3]

Six years after Brand posed these questions, this project attempts to follow the thread by investigating the continued feasibility of creating film elements for preservation and exhibition through a survey of photochemical preservation practices within the film archiving community.

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[3] Bill Brand, "Artist as Archivist in the Digital Transition," *The Moving Image* 12, no. 1 (Spring 2012): 95.

Although film preservation at large continues shifting away from photochemical methods, film-to-film preservation techniques are neither obsolete nor antiquated. It is essential for stewards of film collections to be cognizant of the extent and current state of digital and photochemical film preservation; a presentation of which is here attempted through researching the history and current availability of motion picture film stocks and surveying active film preservation labs. This culminates in a snapshot of what is still possible and still practiced in the photochemical realm, how it has evolved, and where it is going as of spring 2018.

This project includes a close look at current film stock manufacturing, film stock discontinuations that affect film preservation work, the extent of photochemical film preservation practices worldwide, and the material support for these practices. The central goal is to provide a clearer picture of the current state of film preservation practices and how different institutions are grappling with the most recent changes in this realm. For caretakers of film collections, knowledge of the current state of photochemical film preservation, such as where, how, and by what institutions it is practiced, will provide a better sense of potential photochemical film preservation models and assist in implementing well-informed preservation strategies.

Specific goals of this endeavor include: determining the availability of film stock for film preservation, demonstrating the material viability of film-to-film preservation, locating collecting institutions with in-house laboratories worldwide, consolidating information on commercial film labs, and conducting a survey of institutions that still engage in photochemical film preservation. The end products of this research will be available to the film preservation community as practical resources and include:

- A comprehensive list of currently available film stocks
- A chronological manufacturing timeline of Kodak intermediate and print film stocks

- An updated and consolidated film lab directory built on existing lists
- A summary of current practices from various film archives and film labs

As many decisions regarding photochemical film preservation work are made by independent organizations and individuals, quantifiable trends and concrete storylines remain out of reach; but this study seeks to present a contemporary glimpse of the field of photochemical film preservation and its major developments. While the advent of digital technologies in film production and exhibition has changed the field of film preservation and some institutions have switched completely to digital workflows for preserving films, others have not significantly altered their traditional photochemical workflows, and many land somewhere in the middle. In fact, there have been multiple cases of new photochemical film preservation laboratories that have been successfully installed in archives worldwide as many commercial labs shut down. While many institutions have reduced their film-to-film work, others have added such capabilities.

Film preservation methods employed by archives depend on many factors including film stock and film lab availability, but also funding, institutional staffing, and especially institutional histories and individual ideologies, which play a major role in how institutions preserve film. While often portrayed as such, film stock and lab equipment availability are not the biggest challenges in actuality; the physical elements that are necessary to continue film-to-film preservation, including film stocks, chemicals, and equipment are still available, and the choice of analog techniques is still a viable one for archives when only the raw material availability is considered. However, there are still large roadblocks to practicing photochemical film preservation today—mainly, the funding to support the work and a transfer of skills and knowledge to new staff members as the previous generation retires.

The Evolution of Film Preservation Methods

While a thorough history of film preservation methods and their evolution is an undertaking beyond the scope of this project, some context to lead into the current state of film-to-film preservation is necessary. Film archiving and preservation has been written about since the very beginning of cinema; Polish cinematographer Boleslaw Matuszewski is often credited with the first writing on the subject in his "A New Source of History," originally published in 1898. A 1995 translation of the piece shows that Matuszewski concluded his proposal for a film archive by noting "I predict an easy and rapid development for these archives."[4] Despite this early awareness of the importance of the medium by the likes of Matuszewski, the majority of motion pictures from the earliest decades of film history do not survive and are considered lost.[5] The early history of film duplication as active preservation demands more study and research, but cases of early preservation activities are documented.

The Imperial War Museum (IWM) in the United Kingdom presents one of the earliest documented instances of an institution engaging in active film preservation by duplicating motion-picture film onto new film stock. The IWM contains the oldest film archive in the UK. From the museum's initiation in 1920, the film archive was designed to keep all official war films, such as *The Battle of the Somme* (1916).[6] IWM's early film preservation efforts are

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[4] Boleslaw Matuszewski, "A New Source of History," trans. *Film History* 7, no. 3 (Autumn 1995): 324. Original published in French on Mar. 1898 in Paris, France.
[5] David Pierce, *The Survival of American Silent Feature Films: 1912-1929* (Washington, DC: Council on Library and Information Resources and the Library of Congress, Sep. 2013), 1.
[6] Penelope Houston, *Keepers of the Frame: The Film Archives* (London: British Film Institute, 1994), 13.

published in a *Film History* journal paper by David Walsh and Roger Smither.[7] Information about these efforts was also gathered through email communication with Walsh.

Between 1921 and 1923, about 80,000 feet of the archive's most valuable WWI-era nitrate camera negatives were copied onto nitrate positive print stock for fear that the originals were deteriorating. Some of this work was repeated between 1931 and 1932; however, these efforts focused on copying much of the same nitrate camera negatives onto 35mm acetate positive film. While Kodak did not manufacture 35mm acetate film this early, 16mm acetate was available since 1923 and Walsh notes that "Kodak would have had no problem running off a special batch for IWM since it was merely a matter of how the coated film was slit and perforated at the end of the production line."[8] Further duplication of WWI-era nitrate originals took place between 1938 and 1939, this time taking advantage of the newly available fine grain duplicating stocks. This continued until 1965 when the museum completed preservation of its WWI-era nitrate negatives. This is just one example of the complicated early history of photochemical film duplication for preservation, including the copying of 35mm nitrate negatives to custom manufactured 35mm acetate film as early as 1937.

Aside from individual cases of active film preservation work, such as the IWM in the early 20th century, more concerted efforts had to wait until the establishment of formal film archives in the early 1930s in large cities such as Stockholm, Brussels, Paris, London, and New York City.[9] This movement was made more powerful with the establishment of the International Federation of Film Archives (FIAF) in 1938. The four founding institutions of FIAF were

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[7] Roger Smither and David Walsh, "Unknown Pioneer: Edward Foxen Cooper and the Imperial War Museum Film Archive, 1919-1934," *Film History* 12, no. 2, (2000): 187-203.
[8] David Walsh, email message to author, Apr. 12, 2018.
[9] Paul Read and Mark-Paul Meyer, *Restoration of Motion Picture Film* (Boston: Butterworth-Heinemann, 2000), 2.

Reichsfilmarchiv (Berlin, established 1935), The Museum of Modern Art Film Library (New York, established 1935), The National Film Library (London, established 1935), and the Cinematheque Française (Paris, established 1936). The early history and influence of FIAF on film preservation methods and ideologies are well documented by Penelope Houston, Anthony Slide, and Caroline Frick among others.

One of the factors in establishing film duplication as a preservation technique was concerns about damaging unique prints during projection. An early conversation capturing these concerns occurred in the late 1940s, beginning when the UK refined its policies for the National Film Library (NFL) at the British Film Institute (BFI), headed by Ernst Lindgren. In her account of the NFL's early years, Penelope Houston notes that the committee in charge of film selection, after consulting with the British Kinematograph Society was advised not to project unique prints because they could get damaged in the process. This marks one of the earliest documented instances of the idea that a preservation master should be created through photochemical duplication before unique prints were to be used for access. The historical solution suggested in this case was to copy the original nitrate onto acetate stock for preservation and use the original nitrate as a viewing print, which is not in line with current best practices.[10] Harold Brown, who began working for the NFL in the 1930s, invented a machine for printing early film when faced with problems the institution faced in duplication and would go on to become an important figure in film preservation by refining techniques used in film printing.[11]

In the early days of cinema, when original elements such as camera negatives were not afforded the archival value that they have now, they were used to create positive prints for

[10] Houston, *Keepers*, 27.
[11] Houston, *Keepers*, 29.

distribution time and time again, resulting in the complete destruction of the negative in some cases. In this era, only black-and-white camera negative and projection print stocks were available for duplication and since no specialized fine grain intermediate films had yet been developed, duplication often resulted in high-contrast prints. This continued until the 1920s, when black-and-white intermediate film stocks were introduced; color internegative stocks were not introduced until the 1960s.[12]

Anthony Slide's influential book, *Nitrate Won't Wait*, recounts the history which led to efforts in duplicating deteriorating nitrate films and which continue to this day. With the mantra of "Nitrate Won't Wait," the main preservation task of many film archives became duplicating nitrate film onto to acetate in order to keep their collection from total loss. Ever since this movement started, and even before then, a major part of film preservation work has involved "migrating films from one format to the other."[13] In addition to migrations discussed previously, David Bordwell summarizes a variety of duplication actions employed at archives for preservation and access throughout history:

> "Paper prints" had to be transferred, frame by frame, to motion-picture film. Likewise, films surviving only in rare formats, like 9.5mm, 22mm, and 28mm, had to be transferred to 35mm so they could be run on standard equipment. Tinted films on nitrate were reprinted on black and white safety film. 16mm films might be blown up to 35mm, and 35mm might be reduced to 16mm for circulation to schools, libraries, and film clubs.[14]

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[12] Read and Meyer, *Restoration*, 3.
[13] David Bordwell, *Pandora's Digital Box: Films, Files, and the Future of Movies* (Madison, WA: The Irving Way Institute Press, 2012), 177.
[14] Bordwell, *Pandora's*, 177.

As the duplication of film on film became the foremost method of preserving deteriorating nitrate film, major film archives started outsourcing such work to commercial vendors, while others established preservation labs on their own premises. Those archives with in-house labs employed experts in lab work and timing who could optimize the look of prints and preservation elements.[15] Eventually, techniques were developed to mitigate color fading through adjusting printer lights. While wet-gate printing techniques were developed and published as SMPTE technical papers in the late 1950s[16], the technique did not become common in US film preservation labs until the 1980s when the Library of Congress purchased their first wet-gate printers.[17] Although lab technology and preservation techniques continued to evolve throughout the latter half of the 20th century, film preservation and restoration remained a fully photochemical affair until the early 1990s.

Since the 1990s, new preservation methods incorporating digital technology have been slowly established in the field of film archiving and preservation. The increasing use of film digitization and digital restoration tools can be demonstrated by comparing two assessments of film preservation written only nine years apart: in 2000, Paul Read and Mark-Paul Meyer, noted that "the only way" to preserve older deteriorating film is "to duplicate them onto modern film stock."[18] At the time of their writing, digital scanning and preservation had not yet become the norm in film preservation. By 2009, Ross Lipman, then film restoration specialist at UCLA Film and TV Archive, wrote that "traditional photochemical techniques are being replaced by digital ones. On a daily basis methods are being devised–and just as quickly revised–to facilitate the

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[15] Bordwell, *Pandora's*, 179.
[16] A series of three papers with the title "Printing Motion-Picture Films Immersed in a Liquid" published in *SMPTE Journal* 66 and 67 between 1957 and 1958.
[17] Janice Allen, interview with author, Mar. 2018.
[18] Read and Meyer, *Restoration*, 1.

translation of images into binary units." In the same essay, Lipman uses the phrase "fast-disappearing photochemical heritage" to refer to this transition, imparting the idea that a change in the medium has the potential to alter the cultural identity of a work as well.[19] By 2012, Bill Brand, whose company BB Optics specialized in optical blowups of small gauge film, considered the results of digital-analog hybrid preservations as "equal, if not superior, to those produced by an all analog process."[20] Since 2014, BB Optics has transitioned fully from optical printing to the use of hybrid and fully digital methods to carry out a wide variety of film preservation and restoration projects.

Despite the steady decline of using fully analog workflows to preserve films, Leo Enticknap noted that in 2013 photochemical film preservation was still practiced by film archives worldwide. He outlines a visit to the BFI conservation center in Hertfordshire where "photochemical printing and processing" was taking place on several motion pictures. Enticknap does go on to mention that this kind of work has become limited to public sector archives.[21]

As this research seeks to demonstrate, despite the sea change in film preservation methods over the past two decades, there are still many institutions that operate in-house film preservation labs and continue to preserve film through photochemical methods. Before considering the current state of the field and the availability of film stocks for preservation in more depth, an overview of the history of base types and their role in preservation can help further contextualize the topic at hand.

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[19] Ross Lipman, "The Grey Zone: A Restorationist's Travel Guide," *The Moving Image* 9, no. 2 (Fall 2009): 3.
[20] Brand, "Artist as Archivist," 94.
[21] Leo Enticknap, *Film Restoration: The Culture and Science of Audiovisual Heritage* (London: Palgrave Macmillan, 2013), 5

Nitrate-Based Film

Nitrate cellulose was the polymer most widely used from the 1890s to approximately 1950 as motion picture film base. The combination of nitrate and the plasticizer camphor made this type of film stock highly combustible and flammable, eventually leading to its demise as the dominant film base. Without edge markings, nitrate film can be incredibly difficult to identify as most tests are not completely conclusive and a combination of tests and data is usually needed to positively identify a film strip as nitrate.[22]

According to the BFI, nitrate seems to last longer than acetate; however, when nitrate starts deteriorating it deteriorates very quickly.[23] Janice Allen of Cinema Arts, who has extensive experience in duplicating nitrate film elements, also believes that nitrate film was a better stock in terms of longevity than acetate.[24] Despite what some may think about the superiority of nitrate to acetate today, the migration of nitrate to acetate was a central preservation activity of many film archives before acetate's flaws became fully apparent and acknowledged.

Acetate elements made from original nitrate ones are abundant in film archives and in many cases have successfully fulfilled their role as protection elements for the deteriorating nitrate original. For example, Arianna Turci of the Cinémathèque Royale de Belgique, notes that for digitization today, when the nitrate elements of a film no longer survive, they turn to acetate duplicates created between the 1970s and 1990s in their in-house lab.[25] This illustrates the importance of the initial migration of nitrate to acetate as without the acetate duplications, their nitrate holdings would have been lost.

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[22] National Film and Sound Archive of Australia (NFSA), "Base Polymers and Decomposition," nfsa.gov.au/preservation/guide/handbook/base-polymers.
[23] BFI National Archive, "Care of the Collections," bfi.org.uk.
[24] Janice Allen, interview with author, Mar. 2018.
[25] Arianna Turci, interview with author, Apr. 2018.

Acetate-Based Film

Although not adopted for 35mm production in the United States until the early 1950s, acetate-based film stocks were manufactured in smaller gauges as safe alternatives to the highly flammable nitrate from very early in the 20th century. Diacetate film was the first form of acetate film base polymers, introduced in the early 1910s as 28mm film. According to Alan D. Kattelle, the French firm "Pathé Freres introduced a camera and projector for their 28mm safety film" as early as 1912.[26] The well-documented introduction of 9.5mm and 16mm on diacetate safety film occurred in the 1920s. For professional film production and exhibition however, diacetate was not considered durable enough to replace nitrate film. Early diacetate films also exhibited deterioration due to plasticizers specific to diacetate detaching from the base and exhibiting a distinct odor of naphthalene or mothballs.[27] Diacetate also "cost twice as much and lasted half as long in projection life" as nitrate film and was used mostly in non-theatrical production since it could not stand up to the repeated needs of theatrical projection.[28]

The development of triacetate stock–sturdier and less-prone to deterioration compared to diacetate–finally made the move away from nitrate possible. Cellulose triacetate was commercially introduced in the 1940s after wartime shortages dissipated, and Kodak made its first triacetate films commercially available in the 1950s. Triacetate film was both inherently less flammable than nitrate film and the addition of fire retarding chemical agents made it even more

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[26] Alan D. Kattelle, "The Amateur Cinema League and its Films," *Film History* 15, no. 2 (June 2003): 238.
[27] NFSA, "Base Polymers and Decomposition," nfsa.gov.au/preservation/guide/handbook/base-polymers.
[28] Houston, *Keepers*, 30.

safe.[29] Although successful in putting an end to the continued safety hazard that was nitrate film, triacetate did not prove to be a stable film base as it was prone to deacetylation over time.

After the rush to copy nitrate films to tri-acetate stock, the replacement plastic base proved to be just as problematic for film archives and preservationists. When introduced in 1948, there was an expectation that acetate film would "outlast its deteriorating predecessor by leaps and bounds."[30] As early as the 1950s, Kodak became aware of acetate deterioration at high temperature through examining films from the government of India that were stored in such conditions.[31] However, the now ubiquitous term "vinegar syndrome" was not even invented by film archivists until the mid-1980s[32] and it was not until 1991 that Kodak finally revealed how acetate film deteriorates due to heat and humidity through a hydrolysis process similar to nitrate film.[33] Some have even considered acetate film to be just as unstable as nitrate, pointing out that today a film from the 1990s may be at risk because of vinegar syndrome.[34]

A 1992 SMPTE paper concluded that while there are anecdotal differences in stability between various manufacturers and batches, the problem is inherent to triacetate and diacetate film bases, and all acetate elements will eventually succumb to this particular type of deterioration.[35] While the chemical reactions are irreversible, the rate of deacetylation can be

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[29] NFSA, "Base Polymers and Decomposition," nfsa.gov.au/preservation/guide/handbook/base-polymers.
[30] Les Paul Robley, "Attack of the Vinegar Syndrome," *American Cinematographer* 77, no. 6 (June 1996): 111.
[31] ibid
[32] Martin Scorsese, Preface to Paolo Cherchi Usai, *The Death of Cinema: History, Cultural Memory and the Digital Dark Age* (London: British Film Institute, 2001).
[33] Les-Paul Robley, "Attack of the Vinegar Syndrome," 112.
[34] Read and Meyer, *Restoration*, 2.
[35] P. Z. Adelstein, J. M. Reilly, D. W. Nishimura and C. J. Erbland, "Stability of Cellulose Ester Base Photographic Film: Part II — Practical Storage Considerations," *SMPTE Journal* 101, no. 5 (May 1992): 349.

slowed down by storing films in a cold and dry climate. Film archivists also isolate 'infected' prints so that their off-gassing does not harm surrounding films.

Despite its prevalence across film collections and soon approaching its fourth decade, the exact causes behind why some acetate films display vinegar syndrome and some do not are not entirely clear to the film preservation community, with films apparently randomly displaying or not displaying vinegar syndrome, regardless of their history, stock type, or storage conditions. With such uncertainty surrounding the fate of acetate films, it is easy to understand why the archival community does not view it as an ideal carrier for their collections, and these films are being migrated to either polyester film or digital files.

Polyester-Based Film

Although polyester film was developed in the 1940s and used as a base for still photographs since the 1950s, it was not commonly used in motion picture film until the mid-1990s. Kodak's first mention of polyester film manufacturing is in 1960, but in relation to film for graphic arts, not motion-picture film.[36] Polyester film is susceptible to the same kind of deterioration as observed with vinegar syndrome and acetate film, but this reaction is so slow that it can be considered non-existent. Although polyester film is not perfect and can exhibit issues such as core set and delamination, these are generally not considered big problems in film archives if the film is wound and stored properly. Other issues with polyester film include the fact that the very tough and difficult-to-tear base can cause problems for projectors, printers and cameras, while the softer emulsion (compared to acetate and nitrate) is more susceptible to

[36] Kodak, "Milestones," kodak.com/dk/da/corp/aboutus/heritage/milestones/default.htm

scratches. At the same time, the high tensile strength of polyester film makes it ideal for withstanding the wear that a cinema projection print experiences.[37]

Overall, polyester is considered to be incredibly stable if stored properly and almost all new prints and intermediate preservation elements created today are made on polyester stock. Some incubation studies from the Image Permanence Institute (IPI) estimate that polyester motion picture base film will last over 1,000 years.[38] Many films would be in far better shape today had polyester been adopted as a film base on a wide scale earlier than it eventually was in the 1990s. Concurrent with the wider adoption of polyester film, high-resolution digitization of film as a preservation practice was on the horizon.

It is at this point, close to the turn of the century, that film preservation and restoration practices begin to change–arguably more than they ever had during the profession's history–by expanding beyond photochemical practices and into the digital realm. It can be argued that this evolution has now resulted in three predominant workflows for film preservation: a fully photochemical film-to-film workflow, a digital intermediate (DI) or hybrid workflow, and digitization.

This last method is less easily defined as film preservation per se, since no new film elements are created–the end product alters the medium of the original object; however, the increasing affordability of high-resolution digital scanners has led to growing adoption of this method. Archives utilizing this workflow expound improved access to their film holdings in the digital streaming age and the increasing affordability of scanners ensures that a wider range of film collections can be digitized and made accessible. This workflow differs significantly from

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[37] NFSA, "Base Polymers and Decomposition," nfsa.gov.au/preservation/guide/handbook/base-polymers.

[38] Les Paul Robley, "Attack of the Vinegar Syndrome," 121.

both film-to-film and hybrid preservation workflows because no new film elements are created. Once the object is scanned, it can be manipulated in the digital realm and accessed through digital technology, and never recorded back out to film. The output of this workflow is a digital scan, with no associated film elements, unlike both completely analog photochemical preservation and the DI workflow.

In order for film collecting institutions to preserve film through either fully photochemical or DI workflows, three major material requirements need to be fulfilled: film stocks, lab equipment, and active in-house or vendor film labs. In order to demonstrate the continued feasibility of workflows beyond that of digital scanning, it is necessary to detail the current state of these components. The most critical component of these workflows is the raw film stock onto which our archival film is to be duplicated.

Film Stock

Before delving into an analysis of film stocks available for preservation work, the parameters of archival film stocks need to be defined. As the film preservation community is aware of the problems with acetate-based film stock, such as vinegar syndrome, the standard practice of film preservation has been to copy onto polyester film stock for the past two decades. Consequently, the film stocks necessary for film-to-film preservation are all polyester-based. While acetate film stocks are still manufactured, they remain predominantly production tools, although they are still used for certain film preservation task. Similarly, while small gauge (smaller than 16mm) and large-format film stocks are still made, only 16mm and 35mm film stocks are used in film preservation when creating new film elements, even if seeking to preserve smaller-gauge films. Since none of the labs or archives interviewed mentioned creating preservation elements on stocks other than 16mm and 35mm only these gauges are considered here. This does not mean that archives should not or cannot preserve films on other formats, as both the stocks, the machinery, and the expertise exists to do so, albeit on a much more limited scale.

Beyond the type of base plastic and gauge, film stocks are divided into several categories based on the type of emulsion and films in each category fit in a particular part of the production or preservation workflow. When considering the various types of film stocks used in preservation, the emulsion, as opposed to the base, is generally what differentiates and defines them. There are some exceptions to this, such as the orange masking, the rem-jet backing, or perforation shape, which are modifications to the plastic base of the film as opposed to the emulsion. The orange masking layer is used in color negatives to improve the performance of the dyes; intermediate color films used for duplication also have this orange masking layer.

Perforation size and shape can also vary between types of film stocks, even if they are same gauge. The Lumiere original film stock had round perforations; today, there are 2 different types of perforations on 35mm film: Kodak Standard (KS) for positive film stocks and Bell & Howell (BH) for negative film stocks. 16mm film is manufactured with only one type of perforation despite the type of stock. Perforations can also differ in the distance that separates them, known as pitch. Print and intermediate film stocks will generally have a longer pitch than camera negative film stocks which results in more accurate image registration and prevents slippage during printing. This is done to avoid frame misalignment during continuous contact printing, so the film on the outside (the one being printed to) has a longer pitch while the film on the inside (the original) has a shorter pitch. The difference in pitch is generally only between 0.2 and 0.4 percent.[39]

By varying these emulsion and base characteristics film manufacturers create stocks with particular purposes in mind. Although individual companies may use different terms to define these, film stocks can be divided into five broad categories, with the latter three being the most relevant to film preservation practices:

- Camera films are negative stocks which are designed for running through the camera to capture images and are least relevant to film preservation practices, although in many cases they are the starting elements that are to be preserved.
- Reversal films are complicated, as they can act both as camera and print films. Today, they are generally not used in film preservation; although, similar to camera films, in many cases they are the starting element slated for preservation.
- Print films are designed to run through a projector and be screened. While

[39] NFSA, “Film Identification,” nfsa.gov.au/preservation/guide/handbook/identification

traditionally an essential component of film preservation, their role has been somewhat diminished, as DCPs and digital access files are now the predominant form in which film images are experienced.

- Intermediate films, are the 'bread and butter' of film preservation. They are not run through a camera or a projector, but through optical or contact printers, fulfilling their role as intermediaries between a starting element and a final print.
- Digital Intermediate/Recording films have only been made since 2007. They are designed specifically for use in film-out machines and to have digital images exposed on them. They have only ever been manufactured in polyester 35mm.

While it is true that film manufacturers have struggled immensely and downsized massively, all of the above film stocks are still manufactured in various gauges—from Regular 8mm reversal film to 70mm print film; in color and black-and-white; for production, exhibition, and preservation purposes.[40]

Active Film Stock Manufacturers

The production of film is the single most important element that is needed to continue preserving film on film. All active motion-picture film manufacturers are profiled in this section, including those that focus mainly on producing camera reversal film for hobbyists and amateur filmmakers. While these companies have less of a role in film preservation than larger manufacturers such as Kodak and ORWO, they are included here to present a comprehensive picture of film manufacturing as it exists at the time of this writing.

[40] See Appendix A: Film Manufacturing Spreadsheet

The decline in the volume of film stock used in production and distribution since the move towards digital projection in theatres is significant and undeniable. This has been a source of concern for the film preservation community as the larger production and distribution sectors have traditionally kept manufacturers afloat and provided them with the most business. The concern is that if this decline in film usage were to continue, even the manufacturers left might shut down. It should be noted however, that the manufacture of film stock is not completely reliant on business from the film industry.

For example, the polyester base material that film emulsion is coated onto, is an industrial product not at all unique to motion-picture film manufacturing. Kodak whose polyester film is branded Estar, continues to create this plastic base for applications in metallization, labeling, and printing.[41] While polyester film manufacturing is not completely reliant on business from the entertainment industry, the same does not apply to the emulsion manufacturing and the process of coating it onto this plastic base. These latter processes are more unique to still and motion-picture film stocks and remain reliant on these businesses. However, it could still be argued that manufacturers such as Kodak and ORWO that have decided to continue film manufacturing, have already witnessed the collapse of these large markets and adjusted their throughput and business models according to the new landscape. Having already adjusted to the monumental decline from the days where billions of feet of print film were manufactured for cinemas, the worst is likely behind these firms.

[41] Kodak, "Kodak Estar," kodak.com/corp/industrial-materials/estar-pet-films/default.htm

Foma

This company in the Czech Republic has been manufacturing film for various industries, including medical, photography, and motion picture, since 1921. While today they manufacture a wider range of industrial and still photography films, they only offer one kind black-and-white reversal motion picture film. The Fomapan R 100 stock is available in small rolls for 16mm, Regular 8mm, and Super 8mm gauges. The company was contacted for further information regarding their factory and plans for continued motion picture film manufacturing, but no response has been given.

German Film Manufacturers

Germany merits a standalone section when discussing active film manufacturers due to the various German brands that currently offer motion-picture film stock. These four companies are ADOX, ORWO, Wittner, and Kahl. Details on each company will be provided in their individual sections below, but some initial clarification is required. ORWO unquestionably operates its own film manufacturing plant in Wolfen, Germany and manufactures raw film stocks from scratch. With Agfa's discontinuation, ORWO remains the only relevant film manufacturer in Europe when it comes to film preservation or large-scale film production. In the case of Adox, Kahl, and Wittner, it is more complicated to determine which ones actually still manufacture film stock–as in operating a factory to make emulsion, base, and coat the emulsion onto the base–and which are using other vendors for film but doing their own slitting and perforating. The answers to these questions are discussed below as far as could be determined. Regardless, these firms sell motion-picture film in small quantities for 16mm and various 8mm gauges and their products are aimed mostly at amateur firm enthusiasts, artists, and independent filmmakers. They remain

unconnected to the field of film archiving and perseveration or the larger film production world that influences preservation activities.

ADOX

The German company ADOX, which specializes in still photography film manufacturing, offers a 50ft cartridge of black-and-white Super 8mm film. The company's response to whether they plan to manufacture other types of motion picture film in 16mm or 35mm was negative: "there are other, larger players in this field and because the movie film market is ultra competitive only producers with the highest efficiency can survive." They went on to mention that ADOX is too small to enter the motion picture film market as even the companies that do it today do not make money.[42]

Wittner

Wittner offers various types of 16mm, Super 8mm, and Regular 8mm film which will be discussed individually. In response to the question of to what extent they are involved in the different stages of manufacturing film stock, they shared this note:

- use supplier A to make emulsion
- use supplier B to make the clear TAC base
- use supplier C to do toll coating
- finishing / slitting / perforating is in house[43]

[42] ADOX, email message to author, Apr. 2018.
[43] Wittner Cinetec, email message to author, Apr. 2018.

The company has been offering a polyester color reversal film stock, Chrome 200D, since March 2013 as a replacement for the Ektachrome 100D months after Kodak's discontinuation of the popular film stock. A note on the Wittner website reveals that the manufacture of this stock has now been discontinued: "five years later, [in 2018] we have to discontinue [Chrome 200D] since the raw stock Agfa RSX-II 200 is depleted."[44] Further clarification from Wittner revealed that the Chrome 200D used to be manufactured for Wittner by Agfa, but the film is no longer offered since the emulsion supply is now depleted.[45] While Wittner still offers 16mm and Regular 8mm Chrome 200D for sale, this is only until their current supply is depleted, just as it has been with Super 8mm.

In addition to the now discontinued Chrome 200D, Wittner lists three other film stocks on their website, all black-and-white reversal for Super 8mm. However, these stocks are currently listed as unavailable and it is unclear whether Wittner will continue to offer them. These include PXR 50 and PXR 100, triacetate film which can be processed to a negative or a reversal positive. According to Wittner the film is "Slit and perforated […] and loaded under clean-room conditions into new and genuine Kodak Super 8 cartridges."[46] And lastly, a film titled AGFA SCALA 200X but sold with a Wittner label, also listed as unavailable. Wittner plans to offer two new motion picture film stocks in the next two months, Wittner Pan Reversal 50 and Wittner Pan Reversal 100, which will be sold in 50ft Super 8mm cartridges.[47]

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[44] Wittner Cinetec, sage-shop.com/epages/WittnerCinetec-Super8-16mm-Film.sf/en_GB/?ObjectPath=/Shops/WittnerCinetec-Super8-16mm-Film/Products/1200.
[45] Wittner Cinetec, email message to author, Apr. 2018.
[46] Wittner Cinetec, sage-shop.com/epages/WittnerCinetec-Super8-16mm-Film.sf/en_GB/?ObjectPath=/Shops/WittnerCinetec-Super8-16mm-Film/Products/1006.
[47] Wittner Cinetec, email message to author, Apr. 2018

Kahl

Kahl offers a wider range of motion-picture films than ADOX or Wittner, including color reversal film. Although these films are labeled with Kahl labels and sold as Kahl brand film, it is unclear whether Kahl actually manufactures motion picture film from scratch. Attempts to gather such information from Kahl through their website's "Contact Us" page have been unsuccessful. The webpages for some of the films do carry a message in red, bold font reading: "New films with MHD 08 - 2018 freshly produced" which implies that the films are indeed newly manufactured.[48] The question still remains as to where the films are manufactured, and why the company is not discussed more widely despite currently offering the only color reversal film stock besides Kodak.

Today, Kahl offers Super 8mm film cartridges which it describes as 'Universal Negative' film that can be developed as either color negative or reversal. These are offered in three different types based on light sensitivity: NC 15 and NC 17, and NC 21. The company warns that they are designed for digital editing and not for projection on film.

Kahl also offers color reversal film in Super 8mm cartridges, 16mm and Regular 8mm. These are regular reversal film stocks which do not carry the warning that they are designed for digital editing. They are meant to be processed as reversal positives and projected. These films are offered in two types based on sensitivity, UT 18 and UT 21.

Kahl offers a Super 8mm negative black-and-white film sold as a roll and not as cartridges. According to Kahl, the NP 27 is "a highly sensitive negative film for exposures under

[48] Kahl Film and TV, kahlfilm.de/content.php?nav=17&productid=26#

unfavorable lighting conditions. Preferred applications are documentary films, current reportages."[49]

Most curious of all, is their Regular 8mm and Super 8mm black-and-white positive print film stock. These are not reversal or negative and not meant for shooting in camera, but rather for the production of positive prints from negative 8mm elements. According to them "KAHL Print 8 is a very fine-grained black and white positive film for the production of positives from the negative in the camera, as well as graphic applications such as film titles." They go on to note that the film is "only for users who develop their own films. We do not accept these films for development!"[50] The use case and target audience for this film remains ambiguous. Further research on this stock could be beneficial to the film preservation community as it offers the potential for the creation of new small gauge black-and-white print elements.

ORWO

The largest film manufacturing operation in Europe is run by Filmotec GmbH, which still manufactures ORWO film stock in Wolfen, Germany. Today the company produces black-and-white negative camera films, print films, and archival films but no color film stocks.[51] ORWO North America (ORWONA), based in Brooklyn, New York, is the company's North American distribution arm. According to George Campbell who runs the Brooklyn office since he started distributing ORWO film in the United States in 2011, the large majority of his business has come from the sale of intermediate films as opposed to camera negative films. ORWONA sells only

[49] Kahl Film and TV, kahlfilm.de/content.php?nav=11&productid=15#
[50] Kahl Film and TV, kahlfilm.de/content.php?nav=16&productid=21#
[51] Filmotec GmbH, "About Filmotec," filmotec.de/?page_id=112&lang=en.

thousands of feet of triacetate camera negative film annually, compared to millions of feet of polyester archival and print film.[52]

Many labs and archives around the world have increasingly turned to ORWO due to Kodak's discontinuation of 16mm intermediate black-and-white films. The Library of Congress National Audiovisual Conservation Center (NAVCC) facility in Culpeper, Virginia is an example of such an institution. NAVCC purchased a bulk order from ORWO in 2012 as Kodak was unable to guarantee a supply due to their bankruptcy at the time.[53] As of 2016, NAVCC was ORWO's biggest North American client, purchasing approximately one million feet of print and archival film biennially since 2011.[54] ORWO has also been successful in fulfilling bulk orders of film stock for the Filmoteca UNAM in Mexico City for their preservation needs.[55]

Ferrania

Famous Italian film directors, such as Federico Fellini, shot some of their films on Ferrania film stock manufactured in Italy.[56] A plan to revive the company's long-abandoned film factory was hatched in 2013 by the owner of the active Italian film lab Movie and Sound Firenze. A successful Kickstarter campaign set the project in motion and resulted in the successful manufacture of one type of still image film so far. By 2016 the company had outlined ambitious plans to eventually manufacture all moving image film stocks, even up to 70mm. [57] In response

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[52] George Campbell, interview with author, Nov. 2016.
[53] Ken Weissman, interview with author, Oct. 2016.
[54] Ibid.
[55] George Campbell, interview with author, Nov. 2016.
[56] Ferrania, "From Bombs to Bombshells," Sep. 2014. filmferrania.it/news-articles/bombs-to-bombshells
[57] "Hello from FILM Ferrania," Nov. 2016. cinematography.com/index.php?showtopic=73220

to requests for an update on these plans and whether the company is planning to manufacture intermediate film stocks for use in archival preservation they shared the following information:

> The good news is that we are planning to eventually manufacture everything you mention. Our co-founder and CTO, Marco Pagni, owns a cinema lab in Florence, Italy that specializes in preservation/restoration and making archival prints. So this segment of the industry is obviously very important to our founders. The key term is "eventually" - because as you probably know, we have a lot of work to do before we are fully capable of our goals. In fact, the general goal of our factory is to be able to produce cinema products in almost a "bespoke" fashion - and to be able to do so sustainably without requiring enormous minimum quantity orders.[58]

The company hopes to offer its first motion picture film stocks in later this year. The failure or success of Ferrania in manufacturing motion picture film stock could be an important measure for the future of small scale manufacturing of such products.

Agfa-Gevaert

Although the Belgian company is no longer an active motion picture film manufacturer, it is included in this section due to their very recent discontinuation of motion picture film products. The company used to offer 16mm and 35mm color print film and sound recording film as of last year. The most recent search for these products online revealed them missing from the company's website–in fact, the entire motion picture products section was gone. An inquiry to the company revealed that production of print film ceased in 2016 and the production of sound

[58] Ferrania, email message to author, Mar. 2018.

film ceased "even longer before."[59] But Agfa-Gevaert continued to sell their backlog until it was exhausted in 2017 at which time the company removed the products and any indication of motion picture film sales or manufacturing from their website. Although the company has no plans to continue motion picture film production, coating lines and polyester base production lines "are still being used for other products (these are not unique for Motion Picture)" but the equipment unique to slitting and perforating motion picture film has been dismantled.[60]

Fuji

Fuji stopped manufacturing all but one of their many types of motion picture film stocks in 2013.[61] Their announcement, at the height of film's decline, further exasperated the already dire state of film manufacturing. However, five years on from their mass discontinuation, they continue to manufacture their Eterna-RDS film stock which is a digital recording film designed for the creation of black-and-white separation masters from a digital color master. The target customers for this film stock are major production studios whose budgets allow for carrying out the expensive three-strip film-out process. Anecdotally, most Hollywood studios still create black-and-white separation masters using digital separation film, although Fuji is not the sole manufacturer of this type of film as Kodak also offers digital separation film.

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[59] Agfa-Gevaert, email message to author, March 20, 2018.
[60] Ibid.
[61] FujiFilm, "Discontinuation of Motion Picture Film Production," Press Release, Apr. 2, 2013. fujifilm.com/news/n130402.html.

Kodak

Most archives and labs worldwide and especially in the United States, continue to use Kodak print, intermediate, and digital intermediate stocks for preservation work. Kodak is now the sole manufacturer of color films used in preservation today. The company's downward spiral began in the mid 2000s and continued until their declaration of bankruptcy in 2012. According to Kodak, in 2012 they "negotiated new contracts for motion picture film with four key studios: NBC-Universal, Paramount, Disney and Warner Brothers."[62] News outlets also reported widely on a deal between Kodak and the major studios in 2015, noting that Kodak had reached a deal with Hollywood studios to continue supplying them with film.[63]

Kodak film stock sales plummeted 96% from 2006 to 2014, from 12.4 billion feet to an estimated 449 million.[64] While at its peak Kodak had approximately 30,000 people in film manufacturing, as of 2015 this number was closer to 300.[65] Kodak also witnessed a significant drop in profits from 2016 to 2017 in its Consumer and Film division, which includes its motion picture, industrial film, and chemical manufacturing units.[66] Even today, Kodak continues to lay off workers and report losses. In November 2017 the company reported having to lay off 425 workers, including 100 in Rochester, NY where film manufacturing takes place.[67] With Kodak

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[62] Kodak, "Milestones," kodak.com/dk/da/corp/aboutus/heritage/milestones/default.htm
[63] Carolyn Giardina. "Kodak Inks Deals with Studios to Extend Film's Life," *The Hollywood Reporter*, Feb. 05, 2015, hollywoodreporter.com/behind-screen/kodak-inks-deals-studios-extend-770300.
[64] Ben Fritz, "Movie Film, at Death's Door, Gets a Reprieve," *The Wall Street Journal*, July 29, 2014, wsj.com/articles/kodak-movie-film-at-deaths-door-gets-a-reprieve-1406674752.
[65] PBS Newshour, "Picturing Kodak's Transformation in the Digital Age," *Public Broadcasting Service,* Interview with Kodak CEO Jeff Clarke, Mar. 23, 2015, pbs.org/newshour/show/kodak.
[66] Sarah Taddeo, "Kodak Profit Down in Q2, but Growth in Certain Sectors," *Democrat & Chronicle*, Aug. 9, 2017, democratandchronicle.com/story/money/2017/08/09/kodak-profit-down-q-2-but-growth-certain-sectors/553755001/.
[67] Ngoc Huynh, "Eastman Kodak Plans to Lay Off 100 Workers in Rochester," *New York Upstate*, Nov. 9, 2017,

having diversified into various fields such as smartphone touch screen and inkjet manufacturing, layoffs and financial losses do not necessarily relate to the film department.

Despite their financial instability, a recent resurgence of Kodak's motion picture film arm activity has become apparent over the last two years. This is exemplified by their purchase and reopening of several defunct film labs in the US and the UK, and their intent to reintroduce Ektachrome film and a Super 8mm camera. In a recent press release they announced that "with new labs in London, New York, Atlanta and more in queue, we are ensuring that every major production hub has a state of the art filmic infrastructure."[68] In addition, the number of films and even TV series originated on Kodak film has been increasing since a low earlier in the decade.

One of the central questions of this project was whether the film stocks necessary for photochemical film preservation to continue are still being manufactured. Most archives, labs, and film preservationists interviewed during the course of this research noted that they can still find the stocks that they need and did not point to film stock discontinuations as a major roadblock in film-to-film preservation.

The contemporary film stocks used in film preservation are profiled in the following section in order to demonstrate their continued usage in preserving pre-print and print film elements. Kodak, ORWO, and Fuji are the companies that still manufacture film stocks which labs and archives need in order to continue film preservation. These film stocks are broadly divided into two categories. First are intermediate and print film stocks designed for use in fully photochemical processes. These are followed by the smaller set of film-recorder optimized and

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newyorkupstate.com/rochester/2017/11/kodak_plans_to_lay_off_100_workers_in_rochester.html.

[68] Kodak, "Kodak Film Lab London Opens at Pinewood," Press Release, Oct. 5, 2017, kodak.com/us/en/motion/About/News/KODAK_Film_Lab_London_Opens_at_Pinewood/default.htm.

DI films designed specifically for use in film-out machines. It is important to note that although the film stocks needed for variable area optical sound preservation are still manufactured by Kodak, this research focuses exclusively on the preservation of moving images.

Film Stocks for Photochemical Workflows

From the earliest instances of duplicating films onto new stocks because of the original's deteriorating condition, up to the work done today to copy nitrate and acetate films onto more stable polyester stock, a fully photochemical process of film-to-film duplication remains a widely-practiced method of active film preservation. In this workflow, the film is first inspected, repaired, cleaned, and then exposed onto raw film stock using one of two printing methods depending on the condition of the starting material and the goals of the preservation project. The exposed raw stock is then developed using a film processor, yielding a new preservation element. From this new element subsequent film prints can be created. If starting from film elements that do not display severe shrinkage, color-fading, or physical damage, film-to-film preservation remains an ideal method of preserving films on its original medium.

As corroborated by several labs and film preservationists interviewed for this project, no major film preservation processes remain out of reach due to a lack of film stocks.[69] There are however, some discontinuations that have inconvenienced preservationists and have made particular processes more difficult and merit further discussion. These are included in the relevant workflows.

[69] Ross Lipman, Jon Wengström, Albino Alvarez, communication with author, Mar-Apr. 2018.

Color Stocks in Photochemical Workflows

There are three film stocks used in the photochemical preservation of color film elements today (see table 1). All three are manufactured by Kodak in both 16mm and 35mm gauges on polyester base. These stocks are not only essential in preserving any type of color film through a completely photochemical workflow but are also the only available options for this work.

Color Intermediate Film		Color Print Film
Kodak Vision Color Intermediate 2242/3242[70]	Kodak Color Internegative 2273/3273	Kodak Vision Color Print 2383/3383

Table 1. Film stocks used in the photochemical preservation of color film today

Kodak Vision Color Intermediate Film can be used to create either a positive or negative element from pre-print positive or negative elements. For example, if starting from an original camera negative, this stock is used to make an interpositive, but when starting from an interpositive, this stock is used to make an intermediate negative element.

Kodak Color Internegative Film is designed for making duplicates from release prints or reversal prints, which is commonly done in film preservation when no original negatives or pre-print elements are available, leaving a positive print element as the only starting option. According to Kodak, this film stock is "intended for making 35mm or 16mm internegatives from reversal color originals or from color prints when the original color negative has been damaged."[71]

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[70] A note on Kodak's 4-digit numbering system for film stocks is necessary. The first digit specifies gauge and base; 1=nitrate 35mm, 2=35mm polyester, 3=16mm polyester, 5=35mm acetate, 7=16mm acetate. The second digit specifies polarity; 2=negative film, 3=positive film. The last two digits specify the emulsion type; 42= color intermediate, 83=color print.

[71] Kodak, "Kodak Color Internegative Film 2273/3273 ESTAR Base," kodak.com/motion/Products/Lab_And_Post_Production/Intermediate_Films/KODAK_Color_Internegative_Film_2273_3273_ESTAR/default.htm.

Finally, all color answer prints or release prints made today are printed onto Kodak Vision Color Print Film. Until 2012, Kodak also manufactured Kodak Vision Premier Color Print film, known for yielding a brighter look with more contrast, but since its discontinuation, Kodak Vision Color Print Film is the only remaining Kodak stock for color prints. In addition, Agfa manufactured their CP300 color print film until 2016, but since their discontinuation due to a decline in profitability, this stock is no longer available.[72]

Using the three film stocks in table 1, any color film element can be preserved today through a fully photochemical workflow. Workflows and the film stocks used in preserving film on film vary based on the starting element that is to be preserved. Whether seeking to preserve original camera negatives, interpositives, reversal originals, or composite release prints, a combination of the raw film stocks in table 1 can be utilized to accomplish this goal.

Preserving Pre-Print Color Elements

A 35mm or 16mm color negative film can be preserved using a traditional photochemical workflow using Kodak Vision Color Intermediate film. After physical repairs, ultrasonic cleaning, and timing, the starting element can be printed–ideally through a wet-gate process which reduces the appearance of scratches on the new element–onto Kodak Vision Color Intermediate stock to create a new color interpositive. This new polyester element will serve as the new preservation master. From this interpositive, a new intermediate negative element can be printed onto the same type of film stock. New prints can then be struck from this second negative onto Kodak Color Vision Print Film.

[72] Agfa-Gevaert, email message to author, Mar. 20, 2018.

In a less common, alternate workflow, the first step of creating an interpositive to yield a new preservation master remains identical; however, the final prints are made directly from the original negative element instead of going through a duplicate negative. Since the demand for projection prints is considerably lower than historically, using the original to create one or two prints could be beneficial as it would eliminate two generations of printing (from original to interpositive, and from interpositive to duplicating negative), resulting in a higher-quality final print. This workflow also reduces the cost of the preservation through reducing the number of pre-print elements. According to filmmaker and preservationist Ross Lipman, the UCLA Film and TV Archive, under the guidance of former Preservation Officer Robert Gitt, pioneered this technique of striking release prints directly from the starting negative element in order to achieve higher quality final prints.[73] Dr. Jan Christopher-Horak, director of the UCLA Film and TV Archive contends that this workflow is still practiced at the archive today.[74] A limiting factor in practicing this alternate workflow is the condition of the original negative. This element has to be in good enough shape to withstand going through a printer at least twice–once for the creation of a new interpositive and once for the creation of a print. In reality, multiple prints may need to be struck in order to get the timing right or create more than one release print.

Preserving Print and Reversal Color Elements

A positive color print element, reversal or otherwise, can be preserved using Kodak Color Internegative Film. After preparation, the starting element is printed onto this stock in order to

[73] Interview with author, Apr. 2018.
[74] Interview with author, Mar. 2018.

create a new negative element which will serve as a preservation master. The new internegative is used to strike a new answer or release print on Kodak Vision Color Print Film.

Although the existence of Kodak Color Internegative Film still allows for the preservation of color print elements, the latest evolution of this stock has caused some problems for film preservation workflows. The elimination of a remjet backing layer from the latest generation of this stock (2273/3273)–which was intact on the previous generation Color Internegative II (272/3272)–causes light penetrating the emulsion of a film to reflect from the base back into the emulsion. This reflection in turn causes a secondary exposure around images of bright objects, resulting in an undesirable reduction in the sharpness. The backing used to function as an absorbing layer which eliminated this undesirable reflection.

Bill Brand, who has considerable experience in the preservation of small-gauge film through optical printing, highlights this as a particular problem in optical printing.[75] In addition, according Laura Major, who works extensively in photochemical film preservation at Colorlab, the lack of this backing in the new generation "is a major problem for optical printing as not having a backing causes a reflection in the printing gate which fogs the image, or creates a halo. It's mostly noticeable on shots with a lot of contrast–the whites in the image will have a sort of red halo around them."[76] As a solution to this problem, Janice Allen of Cinema Arts suggests using Kodak acetate camera negative stock instead because it still maintains the remjet backing. According to her, the Kodak camera negative yields the same results as 2273/3273 if developed and printed properly, and the camera stock being acetate-based is not a problem if the new element is stored properly.[77]

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[75] Conversation with author, Nov. 2017.
[76] Email message to author, Mar. 2018.
[77] Interview with author, Mar. 2018.

Black-and-White Stocks in Photochemical Workflows (35mm)

Summarizing the use of film stocks for black-and-white film-to-film preservation is more complicated than the discussion of color film duplication for two reasons. First, unlike color film which is only manufactured by Kodak, there are multiple vendors for black-and-white print and intermediate film stocks. In addition to Kodak, ORWO also manufactures both 35mm and 16mm black-and-white stocks that play a role in the creation of new preservation and print elements. Secondly, as Kodak no longer manufactures 16mm black-and-white intermediate stocks, 16mm preservation workflows are reliant exclusively on ORWO film. Despite these complications, the actual photochemical processes of black-and-white film-to-film preservation are simpler than those for color film preservation.

As summarized in table 2, black-and-white duplicating positive and negative film, and print film stocks are available in 35mm from both Kodak and ORWO.

BW Intermediate Film (35mm)		BW Print Film (35mm)
Kodak Duplicating Positive 2336	Kodak Duplicating Negative 2234	Kodak Black-and-White Print 2302
ORWO Duplicating Positive DP31	ORWO Duplicating Negative DN21	ORWO Print Film PF2 (V3)

Table 2. Film stocks used in photochemical preservation of 35mm black-and-white film

In order to preserve a 35mm black-and-white element, either Kodak, ORWO, or a mix of the two can be used. After preparation, the element is printed onto either duplicating positive or negative stocks, depending on the starting element's polarity, to create a new fine grain intermediate element. This new element will serve as a preservation master and can be used to create subsequent fine grain elements or prints using Kodak or ORWO stocks.

As was the case with preserving color negative film elements, an alternate workflow of creating a new fine grain duplicating positive as a preservation element, and striking prints directly from the original negative–in order to increase print quality and reduce cost–is also an option for preserving black-and-white negative elements.

Black-and-White Stocks in Photochemical Workflows (16mm)

As summarized in table 3, Kodak no longer makes fine grain duplicating negative or positive film in 16mm, leaving ORWO as the only option for the creation of intermediate black-and-white preservation masters. However, Kodak and ORWO both still manufacture 16mm print film.

BW Intermediate Film (16mm)		BW Print Film (16mm)
Discontinued	*Discontinued*	Kodak Black-and-White Print 3302
ORWO Duplicating Positive DP31	ORWO Duplicating Negative DN21	ORWO Print Film PF2 (V3)

Table 3. Film stocks used in photochemical preservation of 16mm black-and-white film

Similar to the examples for color film and 35mm black-and-white film, film stocks are available to preserve all 16mm black-and-white film elements using a fully photochemical workflow. The following example illustrates a workflow for preserving a 16mm black-and-white print or reversal element

Preserving Print and Reversal Black-and-White Elements (16mm)

If the starting element that is to be preserved is a 16mm black-and-white print or reversal element, new preservation fine grain elements can only be created by using ORWO film, although answer prints and release prints can be created using either ORWO or Kodak stock. After repairs, cleaning, and timing, the starting element can be wet-gate printed onto ORWO DN21 film stock, yielding a fine grain duplicating negative to serve as the new preservation master. From this element, new prints can be created on either ORWO PF2 (V3) black-and-white print stock, or Kodak's 3302 print film stock.

As previously mentioned most labs and archives indicated that the stocks they need for photochemical film preservation are still available. However, some mentioned the discontinuation of Kodak Fine Grain Duplicating Negative (3234) and Kodak Fine Grain Duplicating Positive (3366) as a problem. However, all of these respondents also mentioned that since ORWO offers equivalents (DN21 and DP31) in 16mm, the situation is not so dire. Some archives and labs still prefer using Kodak's black-and-white fine grain stocks. For example, Anthology Film Archives and Academy Film Archives, both of which work extensively in the photochemical preservation of experimental and Avant-garde 16mm films, purchased bulk amounts of 3234 and 3366 in order to continue preserving on Kodak stock.

This kind of mass custom purchase is still possible today as the film stocks themselves–meaning the specific type of emulsions coated on polyester base–are still manufactured as evidenced by their availability in 35mm. The problem is that Kodak simply no longer slits or perforates these stocks down to 16mm due to low demand. In response to an inquiry regarding the minimum order required for Kodak to slit these stocks down to 16mm, a Kodak representative replied that the minimum order per type of stock is 84 rolls of 2000ft film, costing

a total of about $48,000 per type of stock.[78] Gauging interest in the film preservation community and their funders for pooling resources in order to place such an order could be a worthwhile endeavor.

As illustrated in tables 1, 2, and 3, polyester film stocks for the preservation of both 16mm and 35mm, color and black-and-white elements through a fully photochemical workflow–i.e. no film scanners or film recorders involved–remain in production. Although Kodak's discontinuation of 16mm black-and-white intermediates has caused some trouble for labs and archives specializing in this work, ORWO has successfully filled this gap. Furthermore, color film intermediate and print stocks are steadily manufactured by Kodak in both 16mm and 35mm gauges. The continued monitoring of the film manufacturing landscape, and the establishment of close relationships with the few manufacturers that remain should be considered a priority for film archivists, as the manufacturing of these stocks into the future enable the preservation of film collections on their original format.

Separation Masters in Photochemical Workflows

One last contemporary film stock specific to film-to-film workflows remains to be discussed before the introduction of film stocks optimized for hybrid preservation workflows. The polyester-based Kodak Panchromatic Separation Film (2238) is designed for making black-and-white separation elements from an original color negative element in order to ensure protection against color fading caused by the instability of dyes in color film negatives. The process involves printing the original color negative element three times on three separate rolls of 2238 film stock: through a red filter, through a green filter, and through a blue filter. The

[78] Kodak, email message to author, Mar. 2018.

result, three black-and-white positive elements, serve as protection masters and can be recombined to create a color internegative by printing through their respective color filters onto one roll of color negative film. This stock has only ever been manufactured by Kodak in 35mm and is still available today.

The creation of black-and-white separation masters through a photochemical process using 2238 is not a common practice today in the preservation community; none of the labs or archives surveyed during the course of this research utilize it for the creation of separation masters. Although some Hollywood studios still create black-and-white separations to protect color films, this is more commonly done today by using digital separation films designed specifically for use in film recorders (Kodak 2273 and Fuji Eterna RDS, highlighted in the next section) as opposed to Kodak Panchromatic Separation Film (2238) which is not optimized for use in film-out workflows. However, before the introduction of digital separation film stocks optimized for use in film-out machines about a decade ago, 2238 was used for the creation of separation masters in film-out machines in addition to being used for the same purpose in photochemical workflows.

Film Stocks for Hybrid Workflows

Many film preservation projects now utilize an alternate method, where film scanners and film-out machines are used in conjunction with photochemical processes to create both digital and film preservation elements. This workflow started becoming common in Hollywood film production in the late 1990s, when films were still shot and projected on film, but scanned in the intermediate stage for color grading and special effects. This method is also commonly used for

the restoration of heavily compromised film elements as interventions such as fixing color fade are easier in the digital realm and difficult to achieve via photochemical methods.

The main difference between hybrid workflows and purely photochemical ones is that in the former film first enters the digital realm via scanning and is recorded back out to film after digital interventions. The resulting film element requires photochemical processing, and subsequent steps such as the creation of projection prints, mirror the film-to-film workflow. The process of creating a film element through a hybrid workflow remains expensive, and the most common professionally manufactured machinery, such as the Arrilaser, are limited to working with 35mm film. However, custom machines created by labs such as Colorlab have made the process more affordable and available for 16mm film preservation projects. Even as of 2012, the cost of a file-to-film transfer was estimated at "tens of thousands of dollars" and by some estimates recording features back to film "appears to be 20 to 80 times more expensive than digital preservation."[79] In addition to being costly, the process is extremely time-intensive.

However, it is generally agreed upon in the film preservation community that film stock is still the most stable way to preserve moving images, even those created digitally. But to what extent does this practice continue for born-digital moving images today? While it is cost-prohibitive for independent filmmakers to output their work to film masters for posterity, the practice is in use for feature releases by some major studios.[80]

It should be noted that before the introduction of digital intermediate film stocks optimized for and exclusive to film-out machine usage, regular intermediate stocks were used in the digital intermediate process. In other words, recording digitized film images back out to film

[79] David Bordwell, *Pandora's*, 184-5.
[80] NBC-Universal, interview with author, Apr. 2018.

predates the creation of film stocks manufactured specially for this procedure. For example, digital restoration projects such as those profiled by Giovanna Fossati in her book *From Grain to Pixel: The Archival Life of Film in Transition* would have used regular intermediate film stocks as DI stocks were not available at that point.[81] However, by the late-2000s, film stocks optimized for film-recorders and aimed specifically at archiving and preservation activities were available from both Fuji and Kodak.

Table 4 lists the three film stocks specific to hybrid workflows that still remain in production. These film stocks have been optimized to run through film-out machines and record digital images on film and are all polyester-based and only manufactured in 35mm, which is the case with all hybrid film stocks. Equipment has not been manufactured on a mass scale which is capable of recording digital out to gauges other than 35mm.

Digital Separation Film		Digital Intermediate Film
Kodak Vision3 Digital Separation 2237	FujiFilm Eterna-RDS	Kodak Vision3 Color Digital Intermediate 2254

Table 4. Film stocks optimized for film-recorders available today for preservation.

Although the stocks in table 4 are all optimized for film-recorder use, they serve different functions and can be separated into two categories: black-and-white digital separation films designed for creating separation masters from digital color files, and color digital intermediate films, designed for the digital intermediate production workflow, i.e. the creation of a final color negative film element to be used for creating projection prints.

[81] Fossati, *From Grain to Pixel,* Chapter 4: Restoration Case Studies.

Digital Separation Film Stocks

Digital separation films are designed specifically for creating black-and-white archival film elements from color digital images. These stocks fulfill the same function as Kodak Panchromatic Separation film highlighted in the previous section but do so using a film-recorder machine. They can be used to preserve either a film element that has been scanned and restored digitally or to create archival film elements of born-digital movies. According to Peter Schade, Vice President of Content Management at NBCUniversal, the company uses this process today for creating black-and-white separation masters of its feature-length productions, the majority of which are born-digital.[82] The two digital separation film stocks in production today are made by Kodak and Fuji. Using either of these stocks, color digital images are recorded three separate times onto three separate black-and-white film rolls.

Kodak Vision3 Digital Separation Film (2237) was introduced in October 2012. Fuji's Eterna-RDS is the only motion picture film stock still manufactured by the company. Although Fuji plans to discontinue more of their still photography film stocks this year, they continue to produce the Eterna-RDS which seems to indicate the continued existence of a market for the film.[83]

Digital Intermediate Film Stocks

Unlike digital separation films which are designed for long-term archiving and protection of color moving images, digital intermediate film stocks were designed for use in production workflows. In the 1990s Hollywood studio productions started use of the DI method in the

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[82] Interview with authro, Apr. 2018.

[83] Michael Zhang, "Fujifilm Killing Off More Films in 2018, and Things Look Grim," *PetaPixel*, Oct. 27, 2017, petapixel.com/2017/10/27/fujifilm-killing-off-films-2018-things-look-grim/.

production workflow—with the practice reaching almost 70% of all studio films by 2007.[84] But these productions used regular intermediate film stocks designed for photochemical work until the technique became so common as to merit the manufacture of film stocks designed especially for recording manipulated digitized film images back out to film. Fuji first filled this niche in 2007 with the introduction of the Eterna-RDI, billed as the "first film stock in the world, designed specially for use in the digital intermediate workflow."[85] Fuji's documentation also explains that the film "offers a significant improvement over conventional non-specific intermediate film stock," [86] highlighting the point that these new class of films are inherently different than all previous types of stocks designed for exposure through cameras or traditional printing methods. Fuji no longer manufactures this stock, but Kodak's Vision3 Color Digital Intermediate 2254–which has been available since 2010–still fills this niche and is now the only color DI film available. According to Kodak, 2254 is an "intermediate film for writing from digital files [and] a DI postproduction path to retain the film look when prints are projected on cinema screens."[87]

So why are these DI film stocks relevant to film preservation work today? As previously noted, many preservation and restoration projects today go through a hybrid workflow in order to take advantage of the very image manipulation tools that made the process popular in post-production. After these digital manipulations–removing scratches and doing color correction

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[84] John Belton, "Painting by the Numbers: The Digital Intermediate," *Film Quarterly* 61, no. 3, (Spring 2008): 58.
[85] Masaaki Miki, Hikaru Murakami, et. al, "Development of Motion-picture Recording Film ETERNA-RDI" Fujifilm Research and Development, 2008, 1, fujifilm.com/about/research/report/053/pdf/index/ff_rd053_001_en.pdf
[86] Miki, et. al, "Development of Motion-picture Recording Film ETERNA-RDI," 1.
[87] Kodak, "Vision3 2254 Technical Specifications," 1, kodak.com/uploadedfiles/motion/VISION3_DI_Film_2254_Technical_Backgrounder.pdf

using specialized software–the new preservation film element is created by recording the corrected digital images back out to these DI stocks.

Due to excessive perforation damage, shrinkage, color fading or other damage, compromised film is sometimes scanned first to allow for digital restoration techniques, or because printing would cause damage to the film. If this starting film is a 35mm color element, after digital interventions, the resulting digital master can be recorded out to the Kodak Vision3 Color Digital Intermediate film, resulting in a new color negative element. This film master can be used for the creation of new prints using the Kodak Vison Color Print Film or simply serve as a protection element to be scanned in the future. A color negative protection element of born-digital color films can also be created using Kodak's DI stock. It is important to note that although 2254 is designed for recording scans of 35mm color film, since it was made for modern productions, any digital color film can be printed onto the stock. Therefore, even a 16mm color element can be preserved using 2254 through a DI process but the new element would be on 35mm.

Custom Solutions for 16mm Hybrid Workflows

As previously noted, professional film-recorders were only built to write to 35mm film. However, there exists at least one example of custom machinery designed to output digital files to 16mm film. Colorlab's director and lead engineer, Tommy Aschenbach, designed the custom machine. Many preservation projects today seek to create new 16mm preservation elements of films originated on 16mm, and this custom machine allows for these projects to take advantage of the hybrid workflow without having to film-out to 35mm. In this workflow, a traditional 35mm film-out machine, such as the Arrilaser, is replaced with a film camera which can record

digital video out to 16mm film. However, the film stocks used in this workflow are not DI stocks; as mentioned earlier, DI stocks were ever only manufactured for 35mm film. In other words, while this custom workflow is essentially the same as 35mm DI workflows using an Arrilaser, regular 16mm black-and-white or color film stocks, such as ORWO DN21 or Kodak Color Internegative, are substituted for the specialized 35mm DI stocks.

Colorlab uses Kodak Color Internegative stock to record digital color images to 16mm color film. The same process can be done using ORWO duplicating negative film DN21 for black-and-white projects. Andec Filmtechnik, a commercial film lab in Germany, also offers the recording of digital data to 16mm negative film. According to their website, one of the services offered is the output of digital data to 16mm and 35mm negative film. It is unclear whether this workflow is utilized for the preservation of 16mm films, as it is in Colorlab, or for other purposes. Andec could not be reached for further comment on their uses of this workflow or whether they use custom machinery. As far as this research has discerned, Colorlab and Andec are the only two labs which advertise the output of digital data to negative film. Further research in this realm could be useful for the preservation of 16mm and small-gauge film using hybrid workflows.

Piql: Preserving Digital Data on Film

While most of the field moves towards digitization of analog materials, there is one company, Piql, that is turning to polyester-based film as an answer to challenges in digital preservation. The challenges of preserving and being able to access digital data over centuries—without having to rely on constant migration, is discussed extensively in the moving image archiving and preservation field and other professions dealing with digital data. New ideas and

technologies are constantly presented and written about.[88] Whether it be images, video, or text, the idea of preserving digital data on film stock has been explored before but has never succeeded in implementation to the extent that Piql Film has today.

Piql, a Norwegian company founded in 2002, has developed a technology to write digital data onto special 35mm film. The company has partnered with Kodak, which manufactures the special Piql Film on Kodak 35mm ESTAR film base.[89] "A high-resolution photosensitive film specially designed for longevity and high density digital writing."[90] In this workflow, a machine dubbed the Piql Writer records digital data on the film, either in the form of binary code (such as QR codes) or in human readable form–this step is akin to how film-out machines operate. A machine called the Piql Processor is used to develop the film photochemically after it has been written. Piql claims that the film will last 500 years under optimal storage conditions if kept in its special container. For retrieval, the digital data written to the film will need to be re-digitized. A special machine called a Piql Reader is used to scan the film and an open source software decodes the data. The technology is marketed as 'future-proof' because it uses the advantages of film as an archival medium. However, this process is still dependent on the future operation of complex scanning and decoding technologies for data retrieval.

To address this central dilemma of digital data preservation Piql offers two potential solutions. First, there is the option to record the data on the film in human-readable form so that a digital image of the *Mona Lisa* or the pages of an important text can be recovered by simply

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[88] Fabio Bergamin, "Entire music album to be stored on DNA," *ETHzurch,* April 20, 2018, ethz.ch/en/news-and-events/eth-news/news/2018/04/entire-music-album-to-be-stored-on-DNA.html

[89] Kodak, "AMIA Projection Workshop," Kodak Motion Picture Film YouTube Channel, 2016, youtube.com/watch?v=KgTbwrmHvPI

[90] Piql, "What we do behind the scenes" 4

magnifying the frame in 100 years. Second, to address the bigger challenge of accessing binary code written on the film that will need to be decoded in the future, they print the source code of the open-source decoding software in human-readable form on the head and tail of each film roll. Theoretically, this measure allows for the recreation of the decoding software in the future.

The company also claims that the film can be decoded by scanning with a compatible digital scanner and using the open source software. It is not made clear what a compatible digital scanner means in this instance. Another potential flaw in this system is the obsolescence of the decoded digital file formats by the time the data is to be retrieved in 500 years. This assumes that computers and scanners of the future will be able to successfully decode the data to begin with.

Despite these concerns, the company has been successful in selling this technology to various archives and museums worldwide such as the National Museum of Norway and the National Archives of Mexico. The Image Permanence Institute (IPI) is also cited by the company as a partner in developing this technology. It is worth noting that before inventing this technology, Piql was successful in creating and marketing the Cinevator film recorder, which claims to have revolutionized the way that 35mm print exhibition prints are made through a direct-to-film recording process. While their original Cinevator model was a standard film recorder capable of exposing digital images onto intermediate film stocks, the Cinevator 5 machine enables the creation of 35mm exhibition prints straight from a positive digital master such as a DCP, ProRes, or a set of DPX files. This includes the writing of positive audio tracks and subtitles onto the film print as well. The resulting positive print requires traditional photochemical processing after it has been exposed. This technology is used by companies such as Cinema Printing Company in London and as well as Labodigital in Latin America.

Lab Equipment

Kodak, ORWO, and Fuji continue to manufacture the film stocks necessary for photochemical film preservation to continue today. In addition to raw film stock however, functioning machinery is required to successfully process and duplicate motion-picture film, making it necessary for a survey of photochemical film preservation to address the current state of film lab equipment manufacturing and maintenance. While preserving the skill set and knowledge for the optimal operation of photochemical laboratory practices to future generations remains a challenge for photochemical film preservation, it is hard to quantify and is outside the scope of this technically minded project. More quantifiable is the state of the equipment used in film-to-film preservation and whether manufacturers of this equipment are active in offering parts and maintenance services. Film printers, processing machines, cleaning machines, and color analyzers are some of the devices needed in order for photochemical film preservation practices to continue.

Today, shooting on film is still widely practiced in Hollywood and beyond, although not anywhere near a decade ago when the majority of motion pictures slated for theatrical distribution were originated and produced on film. It can even be argued that originating on film has had somewhat of a resurgence in the past 2 years, with even TV shows and commercials now sometimes originated on 16mm or 35mm film.[91] Consequently, the practice of developing film, especially color 35mm negative, is still supported by the production market. This resurgence of film can also be evidenced in Kodak's recent acquisition and continued operation of film labs in London, New York, and Atlanta. The latest Kodak film lab is a new facility in Queens, NY, equipped with two color negative processing lines. Considering the reliance of film preservation

[91] Kodak Lab New York, interview with author, Mar. 2018.

on larger commercial forces which are driven mainly by production and post-production needs, the increase in originating high-profile projects on film is good news for film preservation indeed.

While many new productions are still originating on film, keeping the commercial need for film processing alive, the photochemical components of these productions usually end at the processing stage and do not extend to printing new film elements. Since the distribution and exhibition of contemporary theatrical releases are almost completely digital there are generally none, or very few, exhibition prints created. As a result, no intermediate elements are printed from the processed negative and no film duplication occurs at all. Consequently, the practice of printing developed camera negative onto intermediates and creating composite prints through photochemical or hybrid workflows has become a niche activity in the production world even for projects originated on film. Although there are examples of both independent and studio films that go through completely photochemical workflows, these remain few and far between and are not enough to exert a considerable influence on keeping printing practices alive for the use of the film preservation community.

When considering the continued existence and feasibility of the distinct processes of processing film and printing film, support from the production community and the minor analog renaissance only extend to color camera negative processing. For example, an increase in the production of Netflix or HBO series on film, or a similar uptick in TV commercials shot on smaller gauges, while beneficial for guaranteeing a continued market for film processing labs, expertise, and equipment, contributes little to a market for film duplication practices or the processing of positive prints.

While a lack of business from the filmmaking and distribution worlds remains a threat to the continuation of analog printing and processing, the manufacturers of equipment necessary for these practices continue to exist. The biggest name in the film lab equipment manufacturing industry today is RTI, a Chicago-based company which was established to manufacture 16mm film inspection machines in the 1970s and is active to this day. For the past two decades, RTI has been growing by acquiring and consolidating many of the major companies that make film processors, printers, timing machines, and film cleaning machines. The firm has created an almost complete monopoly on the equipment needed to run a film lab. Two of their most significant acquisitions were of the BHP and Treise companies. They acquired BHP, a film printer manufacturing company, in 2000. RTI acquired the Treise Engineering company as well, which manufactures large film processing lines. Other firms acquired by RTI include the film cleaning machine manufacturer Lipsner Smith, Filmlab Systems International which makes color analyzer or timing machines, and Calder, another processing machine manufacturer. According to their website, RTI still maintains, and will manufacture on demand, any of these systems or spare parts for them, making it possible to keep these relatively simple machines running well into the future.

RTI's main competitor in this field is Photomec, a UK-based company, which manufactures one of the most used brands of film processing machines worldwide. According to their website, they have "manufactured more continuous film processing machines than any other manufacturer and installed them in more countries around the world than our competitors."[92]Most recently, Photomec installed two of their processing machines in Kodak's new lab in Queens, New York. Photomec's CEO, David G. Wright, was recently visiting the

[92] Photomec, photomec.co.uk.

machines they had installed at the Kodak lab and provided the following information about the company's past and current operations in an in-person interview to the author. The company has been building film processing machines to order since 1946 and maintains the capability to fulfill such orders today. Photomec's business remained steady until 2010, when they built 12 new machines, but orders have really slowed down since and they have not built many new processors since. The last new machines were built in 2012 on an order from the King of Thailand, who utilized them to set up a dedicated lab for his staff of cinematographers. Since 2012, Photomec has not manufactured new processors but has continued to install used and refurbished processors from defunct labs in new ones, such as the new Kodak Labs in London and New York. The company manufactures the more expensive and high-end brand of processors, compared to the RTI brands (Treise and Calder) and their models range in price today from $250,000 to $750,000.[93]

Other companies that manufactured lab equipment include the German company Arri, which from the 1960s until the early 1980s sold "a wide variety of laboratory equipment to film processing facilities worldwide."[94] Today, Arri is one of the most prominent manufacturers of film scanners and film recorders used by film archives, and despite a long history of manufacturing lab equipment in Germany–including the "first large film processor with friction drive" in 1927–offers no support for photochemical processes.[95]

As evidenced by both RTI and Photomec's current ongoing operations, the challenges facing film lab equipment differs from those facing the more complicated technologies in videotape playback decks. Film processing and printing equipment, while by no means in

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[93] David G. Wright, interview with author, Mar. 2018.
[94] Arri, "Laboratory Equipment," 100.arri.com/timeline/event/59a85e9149bd8774e2740a6f
[95] Arri, "Film Processing," 100.arri.com/timeline/event/59a84b992d17e674db123722

demand as new products, are also not facing the same severe obsolescence that magnetic media decks face due to their complex electronic components. The manufacture, maintenance, and refurbishing of film printers and processors, most of which operate on mechanical technologies that have remained unchanged for decades, do not pose an immediate threat to photochemical film preservation.

Film Laboratories

In addition to film stocks and lab equipment it is necessary to cover the film laboratory landscape worldwide in order to gain a complete understanding of the current state of film-to-film preservation As both fully photochemical and hybrid film preservation techniques are reliant on the existence and continued operation of film laboratories with processing and printing capabilities, a survey of both commercial and non-commercial labs was a central part of this research. While the results shared here are not comprehensive, research will continue beyond the completion of this thesis in order to achieve this goal.

Before the collapse of the 35mm film distribution and exhibition industry that resulted from most movie theatres switching from film to digital projection, film labs all around the world made the bulk of their profits by churning out a vast number of composite release prints. In some cases, their printing and processing equipment ran on a 24-hour basis. While the decline in shooting on film, and the resultant decline in negative processing also impacted the business of film labs, negative film processing was only a fraction of the amount of positive processing for exhibition prints. The decline of film consumption in production, post-production, and exhibition contributed to the mass closure of film labs that started in the late 2000s and continues to this day, although at a much slower pace.

Prominent examples of these closures in the United States include:

- 2014 - Deluxe Hollywood
- 2014 - Film Lab New York
- 2013 - Astrolab Chicago
- 2011 - Technicolor Canada

Mass lab closures prompted organizations such as FIAF, AMIA, and Indiana University Libraries (IU) to create and maintain directories of active photochemical film labs; which added to a directory of labs already being maintained by Kodak. These lists include commercial labs large and small, as well as those run by film archives on their premises for preservation purposes. In order to survey the current state of film-to-film preservation, these lists proved to be an invaluable resource and what follows is largely built on the work already done by the aforementioned institutions. This research provides a consolidated and updated list using all these sources with the eventual goal to serving as a comprehensive resource for the archiving and preservation community worldwide.

FIAF List

FIAF maintains a "List of All Photochemical Film Labs Operating in the World Today" on their website. According to this webpage:

> As a resource for FIAF affiliates and beyond, FIAF has been working on consolidating and adding to various existing lists of film laboratories still in operation around the world with all relevant contact information, websites, country and when relevant, the formats supported. The focus of the updated list is primarily photochemical labs. This list includes commercial film labs, film archives' in-house labs, and artist-run labs. To the best of our knowledge, this list is accurate as of 1 November 2015.
>
> This list is the result of a consolidation and revision of data from previous similar efforts by FIAF (2013 film lab survey), AMIA's Film Advocacy Task Force, Mick Newnham (Australia National Film and Sound Archive), Andrew

> Oran (Fotokem), Christian Richter (Kodak), and the many FIAF affiliates who responded to our request for updated information on lab closures.[96]

In addition, according to Rachael Stoeltje, Director of Indiana University Libraries Moving Image Archive and a member of the FIAF Executive Committee, the FIAF lab list was developed by consolidating several lab lists. A graduate student at IU spent a summer consolidating these lists and calling labs to verify that they were still active. Stoeltje also notes that the final list is the one visible on FIAF's website and is also replicated on the IU website.[97] However, today the FIAF and IU lists differ significantly, with the IU list having about 30 more labs listed than the FIAF list. According to the results of this research, this seems to be due to lab closures that have been reflected on the FIAF list not having yet been updated on the IU list.

According to Christophe Dupin, FIAF Senior Administrator, Stoeltje and he maintain the film lab list today. Both Dupin and Stoeltje have committed to incorporating the updates in this research on the FIAF lab list.[98] This paper and Appendix B, a spreadsheet consolidating the lab research, will be shared with them upon completion of this research.

Indiana University List

Although IU's list shares an identical title and is meant to replicate FIAF's, the two labs currently have significant differences. IU's list still served as one of the references for this project because it captures a higher number of labs than any of the other three lists. As Stoeltje manages this list in addition to the FIAF list, it will also be updated as a result of this research.

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[96] FIAF, "List of All Photochemical Film Labs Operating in the World Today," fiafnet.org/pages/e-resources/film-labs-list.html

[97] Interview with author, Mar. 2018.

[98] Email message to author, Mar. 2018.

AMIA List

AMIA's Film Advocacy Task Force has also created a directory of US and International film labs. According to their website these lists are not "comprehensive, and also may not include some specialist laboratories."[99] The AMIA lists seem to have been incorporated into the FIAF list in the past, and there is much overlap between the two as there is between all these lists. The lists produced by AMIA do not include most of the preservation labs in film archives and seem to focus mostly on commercial film labs. The results of this research will also be shared with the Film Advocacy Task Force in order to help in updating their lists.

Kodak Laboratories Directory

According to research into Kodak's archived websites using the Wayback Machine, the company has been keeping a directory of international film labs since at least August 2008.[100] Kodak provides no information on how the lab list is compiled and how current it is. Attempts to reach Kodak to gather information on this list were not successful. While the list seems to focus mostly on commercial labs, some preservation labs, such as the one operated by The National Archives and Records Administration (NARA) in the United States, are mentioned on the list as well.[101] Attempts will be made to share the results of this research with Kodak.

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[99] AMIA Film Advocacy Task Force, "Laboratories – International," filmadvocacy.org/resources/motion-picture-film-labs-artist-run/motion-picture-film-labs-international/

[100] Kodak, "Lab Directory," Archived Webpage, Aug. 1, 2008, web.archive.org/web/20080801170949/http://motion.kodak.com:80/US/en/motion/Support/Laboratories_Directory/index.htm

[101] www.kodak.com/motion/support/laboratories_directory/index.htm?blitz=off

Table 5 summarizes some data from the four lists mentioned above. Although other lists by other organizations exist, due to their higher visibility and relevance to the archival field, these four will be the focus and starting point of this research.

List	Kodak	AMIA	FIAF	Indiana University
# of Labs on List	89	122	153	183
Last Updated	Unknown	June 2015	Nov. 2015	Nov. 2015

Table 5. Previously compiled film lab directories

In order to gain a comprehensive picture of potentially operational film labs today, these lists were consolidated into a 'master list,' which is likely to capture all possible active labs in the world; this list will hereby be referred to as 'the master list.' Using the master list, labs were systematically researched and contacted to gather first-hand information on their activities, especially as related to film-to-film preservation. The master list also includes labs which were found to be active during the course of this research but not mentioned on any of the four lists. Some results from this research are presented in table 6.[102]

Total	Active	Closed/No Photochemical	Unconfirmed
202	79	41	82

Table 6. Consolidated mast list

Of the 202 labs on the master list, 79 were confirmed to be active photochemical labs, 41 have either closed or suspended their photochemical labs, and the status of 82 are yet to be determined. During the course of this research, a few labs were found that did not exist on any of the four lists; these were added to the master list.

[102] See Appendix B which contains the master list and more detail about individual labs

Despite the availability of these lists, an amount of misinformation and mischaracterization regarding the current state of film labs and printing and processing facilities persists which partially prompted this update and further categorization of labs. For example, while IU lists 70 labs in Europe, a 2013 story in *Variety* claimed that "there is only one major lab left in Europe, and it's unlikely to last through the year."[103] Even though the IU list seeks to include *all* existing labs and the *Variety* article qualifies its claim by saying one *major* lab, there are still more than just one lab that can be defined as *major* in Europe. The hope is that the consolidation of information on film labs will foster conversations on the issue and result in a more accurate sense of this field both for the moving image archiving and preservation community and other stakeholders.

Methods and Questions

The methods used to inquire about the status of each lab and the questions posed to each varied widely based on the type of lab, extent of prior familiarity, and whether or not English was the primary language spoken where the lab was located. First, Google searches were conducted to see if whether a lab had an active web presence. In many cases, the hyperlinks provided on the Kodak, FIAF, or AMIA lists provided a good starting point but were not always reliable. Even if a website was online and included information on the lab and its services, attempts to establish direct contact were made in order to gather the most current information as websites are not necessarily up-to-date and may not reflect whether a lab is actually operational. When possible live or archived websites accessed through the Wayback Machine were used to

[103] Andrew Stewart and David S. Cohen, "Filmmakers Lament Extinction of Film Prints," *Variety*, Apr. 17, 2013.

locate contact information for the labs. Once contact information was gathered, an email inquiry was sent. Various email templates were devised at the beginning of the project which were modified before sending depending on various factors mentioned previously. A standardized survey of questions was decided against due to the enormous variety of film labs on the master list. Labs were sometimes contacted through their Facebook Messenger service or even LinkedIn accounts if those were the only available options. The questions posed in cases of successful contact sought to gather information on the following subjects:

- Level of current activity and photochemical capabilities
- The extent of involvement in photochemical film preservation work
- The challenges in acquiring film stock and equipment
- Outlook for the future of their lab operations
- Information on other labs still operating in the region

With the last question, each responsive lab was given the opportunity to share information about the lab scene in their region or country, helping the author to gather a complete picture of film labs in a particular country even if some labs could not be reached. In rare cases, this probe led to the discovery of film labs not listed on the master list.

If a website was not available and contact information could not be gathered, the Internet Archive's Wayback Machine was utilized to access archived web pages of the film lab. Through this method, the approximate time period that a lab's website went offline was used as a potential indicator of its closure date. This assumption was only made as a last resort, and such labs were not marked as definitively closed unless other corroborating information was found. News articles also served as a valuable source, especially for confirming the closure of film labs.

At the moment, many labs are yet to be contacted or researched. Research for some labs did not yield any information as neither current or archived websites, nor news articles or social media accounts could be located. Due to the scope of the project, some labs and archives necessarily received more attention than others. This was partially dependent on how responsive labs were but also due to the short time span allotted for the project.

Types of Labs

One goal of this survey was to classify labs according to categories that may be useful for quantifying the extent of photochemical film preservation worldwide. As the research evolved, two very broad categories became apparent: preservation labs and commercial labs. Commercial labs were further divided into professional and amateur labs. Of course, in reality, there is much overlap between these categories and single labs can and do fulfill all of these roles, but the categorizations proved useful nonetheless. It is important to emphasize that these categorizations are not made on any of the source lists or by the labs themselves. Rather, they were assigned to each lab on the master list by the author during the course of this research in order to assist with surveying the landscape of film-to-film preservation more specifically.

Preservation labs were defined as in-house labs maintained by film collecting institutions. This definition encompasses organizations with a film collecting mission, whether overseen by a government or existing as a non-governmental entity. While countries and regions have different laws and methods of running such institutions, all film labs in this category were set up primarily for preserving an existing film collection as opposed to working predominantly for current productions, student projects, or consumers. These lines can sometimes be nebulous as some of the labs profiled will illustrate. Examples of labs in this category include the Library of

Congress' National Audiovisual Conservation Center in the United States and the Thai Film Archive in Bangkok.

Commercial Professional labs were defined as those capable of handling at minimum 35mm photochemical processing or printing. Many of the labs in this category work on photochemical preservation and restoration projects as well, but they are not collecting institutions. Examples of labs in this category include Fotokem in Los Angeles and TF CineNova in Germany. The third category of labs was defined as Commercial Amateur labs; those with services geared towards consumers and amateur filmmakers with capabilities in printing or processing gauges smaller than 35mm. One subset of this category are labs that specialize in processing undeveloped rolls of expired or discontinued film. Examples of labs in this category include Nanolab in Australia and ArcoIris in Argentina.[104]

Before presenting the results of this research, a different type of lab which will be largely left out of this conversation needs to be noted: artist run labs. Some of these labs, such as Negativeland in Queens, NY, were started as a response to the collapsing of the film industry and were made for and by artists with a desire to continue working in the film medium. These labs are usually capable of 16mm or 8mm black-and-white printing and processing on a small scale. By maintaining a frequently updated directory through the website filmlabs.org, these artist labs form a distinct conglomerate with very little overlap with Preservation or Commercial labs as defined by this project. There are currently 46 artist-run labs around the world, the great majority of which are located in Europe.

[104] See Appendices for consolidated information on commercial labs.

Preservation Film Laboratories

The most important category of labs to consider for a survey of film-to-film preservation are the preservation labs. These are in-house labs of national or regional film archives, film libraries, museum collections, university film archives, or any type of film collecting institution. Many of these institutions are FIAF members or associates, or otherwise active participants in the audiovisual preservation community. Consequently, the continued existence of their film labs and the degree to which they are active today are strong indicators of the extent to which the field still practices film-to-film preservation. In order for this practice to continue, film preservationist need to be aware of the existence of these labs and their current practices. The labs themselves and the institutions that run them are also best served by increased communication with each other regarding their film preservation ideologies, methods, and challenges. One of the aspirations of this project is to foster the creation of a consortium of these film labs, perhaps nested in AMIA or FIAF, in order to facilitate an exchange of information regarding their photochemical film preservation work.

According to this project's categorization, the master list includes 28 such labs, 19 of which were confirmed to still be photochemically active, 3 of which have stopped their lab work, and 9 which remain to be confirmed.

# on Master List	Active	Suspended Lab	Unknown
28	19	4	5

Table 7. Status of Preservation Film labs worldwide

Library of Congress: National Audio-Visual Conservation Center – Culpeper, Virginia, USA

The Library of Congress (LOC) started their nitrate film preservation program in 1958 and inaugurated an in-house film preservation lab in 1970. The LOC's National Audio-Visual Conservation Center (NAVCC) in Culpeper, VA, also known as the Packard Campus is one of the best-equipped facilities devoted to AV reformatting, storage, and preservation in the world. NAVCC became operational in 2008 and includes an active film lab in which all of LOC's in-house photochemical film preservation work takes place. Although designed to be the pinnacle of archival preservation work, NAVCC film lab has faced some unforeseen challenges since the facility opened. While the lab was designed for both color and black-and-white processing, they have not operated their color film developers due to unanticipated environmental restrictions on disposing chemical waste that results from color processing. As a result, although NAVCC has several lines of color processing machines installed, they have not been used at all. RTI's Treise Engineering Company installed the film processors at NAVCC.[105]

In 2011, LOC requested bids from film stock manufactures on a four-year contract to supply film stock to NAVCC for preservation work. Kodak, in the midst of massive sale losses, was unable to place a bid due to their uncertain future in film manufacturing. Although LOC encouraged Kodak to bid on the contract whether or not they could guarantee a four-year supply, the two parties could not come to an agreement. ORWO, which had just recently established a distribution arm in North America, was able to bid on the contract and has supplied NAVCC

[105] RTI, "Film Processor for the New Library of Congress Film Archive in Culpepper, VA," rtico.com/wp-content/uploads/2015/12/Library-of-Congress-Film-Archive.pdf

with millions of feet of black-and-white film stock ever since. The facility has recently also acquired film stock from Kodak.[106]

National Archives and Records Administration – College Park, Maryland, USA

NARA is a branch of the US government which houses a large film collection. Film deposits to NARA started in 1939 and they have operated an in-house film preservation lab in different locations since the 1950s. Today, their film lab is active and has been operating in NARA's current facility in College Park since 1992. Their lab capable of optical and contact printing, as well as full black-and-white processing.

They have three contact printers. Two of these are BHP printers, one used for dry printing and one used for wet-gate printing. They also use a vintage Bell & Howell Model J printer for preservation-quality dry contact printing; all 35mm black-and-white work is done on this printer, which is extremely gentle and can duplicate film at slow speeds. Today they also operate three film scanners which they use to serve reference access requests. NARA did not have a digital preservation and storage infrastructure until 2016.

As illustrated in table 8, the amount of film preserved by NARA has plummeted from more than 2 million feet in 2004 to less than 300,000 last year. According to Christina Kovac, Supervisory Motion Picture Preservation Specialist at NARA, this decline has been neither due to challenges in acquiring film stock nor to the advent of film digitization at the facility, but mostly the result of staffing cuts at the institution; her division is now left with only 3 staff members. Kovacs notes that NARA's legal mandate to provide citizens with access to

[106] Ken Weissman, interview with author, Nov. 2016. George Campbell, interview with author, Nov. 2016.

government records requires them to focus on serving access requests which in turn leaves less time and resources for their film duplication activities.[107]

Fiscal Year	Digitized for Reference (ft)	Preserved Photochemically (ft)
2004	-	2,284,129
2005	-	1,682,042
2006	-	1,655,000
2007	-	1,186,829
2008	-	1,441,603
2009	-	1,913,333
2010	326,319	1,337,949
2011	368,437	1,101,322
2012	500, 860	532,767
2013	539,161	677,293
2014	542,746	474,544
2015	840,746	350,437
2016	602,980	209,543
2017	786,447	281,028

Table 8. Data on NARA's photochemical film preservation and digitization operations.[108]

NARA is an example of an institution which holds a large and growing film collection equipped with an in-house lab which is ran by a preservationist dedicated to continuing photochemical film duplication. However, the lab's film-to-film work has recently been reduced

[107] Christina Kocvac, phone interview with author, March 19, 2018.
[108] Christina Kovac, email message to author, Mar. 2018.

to a slow pace due to the decline in staffing over the last 5 years. Consequently, they have seen a decline of 90% in their photochemical preservation work over the last 5 years and have not done any optical printing for a few years.

NARA also works with outside vendors to create intermediate elements and access prints of their film items to serve access requests. Requestors have the option of using vendors or NARA's in-house lab. If requestors want a copy of a film from which no intermediate already exists, they must either pay the cost for NARA to make an intermediate or wait until NARA has made one according to their own timeline. NARA maintains a list of vendors approved for motion picture copying. The list includes two labs listed as being capable of film-to-film, BonoLab and Colorlab. BonoLab's website indicates that they are no longer capable of photochemical duplication. This leaves NARA's in-house lab, and Colorlab as the only two labs that do photochemical copying of films held by NARA to serve access requests.

UCLA Film and TV Archive / Packard Humanities Institute – Santa Clarita, Californian, USA

The UCLA Film and TV Archive (UCLA FATVA) has been engaged in film-to-film preservation since 1976 when Robert Gitt was hired as their first film preservation officer. The lab work was outsourced until the mid-1990s when they installed an in-house dry lab in their Los Angeles location. Starting in the mid-2000s, The Packard Humanities Institute (PHI) funded the development of a new preservation facility and nitrate-storage vaults for UCLA FATVA in Santa Clarita, California. This state-of-the-art facility is referred to as the PHI Stoa and is shared between UCLA FATVA and the PHI. While the two have traditionally maintained a close relationship, they are still two distinct entities with separate missions. The PHI Stoa nitrate vaults became operational in 2008 and the preservation facility sometime later. Today, the PHI Stoa

houses an active, dry film lab with a staff of 5 people, 2 panel contact printers, 2 optical printers, and a color analyzer. All film development work is outsourced to Los Angeles area labs such as Fotokem.[109]

According to the UCLA FATVA's director Jan-Christopher Horak, their film preservation work is still 90% analog and the creation of new preservation and access film elements are required for new restorations. Horak notes that the archive used to follow FIAF's guidelines on new film elements that should result from a preservation project and these included an intermediate negative, an optical track negative, a fine grain positive, and at least two prints. Today, the archive's policy has changed due to lesser demand for film prints and the advent of hybrid preservation methods although they remain dedicated to creating film elements. For example, if preserving a nitrate negative today, they might make an intermediate positive element for preservation and create prints straight from the original negative instead of going through a duplicate negative. This is feasible since they only need to strike one or two prints at most. Digital exhibition copies such as DCPs can be created by digitizing the newly created interpositive element.[110]

The archive occasionally utilizes hybrid methods for film preservation. For example, a recent project to preserve a film starting from an extremely damaged original camera negative required the film to be digitized first. Today, preserving film through photochemical workflows still remains less costly for the archive than DI methods as the PHI Stoa does not have a robust digital repository and storage infrastructure in place. However, they are in the process of raising funds for a digital repository and once such digital preservation infrastructure is in place, UCLA

[109] Information gathered during visit to the facility, Jan. 2018.
[110] Jan-Christopher Horak, interview with author, Mar. 2018.

FATVA plans to do more film preservation and restoration through hybrid workflows. Horak insists that the final outcomes of such projects will still include 35mm master and print element regardless.[111]

The PHI and UCLA FTVA have maintained a close relationship over the past two decades over which PHI has funded much of the UCLA FATVA's film lab work and lab staff salaries even before the construction of the PHI Stoa facility in Santa Clarita. This relationship has changed as of January 2018 and while PHI still funds the film lab and the salaries of the lab staff, whereas before they were UCLA FATVA employees, they are now PHI employees. PHI now essentially manages the film lab and staff at the PHI Stoa and the lab now functions more as a vendor for UCLA FATVA whereas before January 2018 it was always run and managed by the archive itself.[112]

The Library and Archives Canada - Gatineau, Quebec, Canada

The Library and Archives Canada (LAC) is responsible for the preservation of Canada's governmental records with the mission to "acquire, preserve and make accessible Canada's documentary heritage."[113] The LAC cares for over 90,000 films including the entire film cache found in Dawson City in the 1970s. The LAC's Gatineau Preservation Centre opened in June 1997 and cost about $90 million to build; this dedicated storage and preservation facility houses an active photochemical film preservation lab. In addition, LAC opened a Nitrate Film Preservation Facility in 2011 which includes storage vaults for of their nitrate film collection;

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[111] Interview with author, Mar. 2018.

[112] Jan-Christopher Horak, Phone interview with Author; visit to PHI and interview with lab members and Patrick Loughney director of PHI.

[113] Much of the information about LAC comes from email messages and interviews with LAC staff Tina Harvey and Dale Gervais

this facility is only for nitrate storage and distinct from the Gatineau Preservation Centre which houses the film lab.[114] In October 2017, LAC announced plans to start construction of yet another facility for preservation in 2019, with a cost of $400 million.[115] This new facility will not include a photochemical film lab.

Photochemical motion picture film duplication at the LAC's in-house preservation lab is unlikely to last beyond five years as the archive moves towards a fully digital workflow for preserving their film collection. Even today, analog film duplication at the lab is only used as a means to create 35mm elements that can be scanned digitally, a unique workflow as far as this research is concerned. Since the LAC is not equipped for scanning 9.5mm and 28mm gauges and holds a large collection of these types of films, they use a wet-gate optical printer to blow up these films to 35mm which their scanner is equipped to digitize. Essentially, they utilize photochemical duplication for material that they cannot digitize. Prior to 2013, the lab used to create a film preservation master, another intermediate element, and reference print copy, resulting in at least 3 new film elements for any film preservation project. Today they only create film elements for scanning, and since they acquired a 4K digital scanner in 2013 they consider preservation masters for film elements to be 4K digital files. Today, new digital preservation masters are created through scanning original elements, even in cases where films have already been preserved in the past using wet-gate printing.

Their lab's analog duplication capabilities include a wet-gate Oxberry optical printer, heavily modified to handle shrinkage. As mentioned, this printer is now used almost exclusively

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[114] LAC, "A Behind-the-Scenes Look at LAC: The Nitrate Film Preservation Facility," LAC Blog, Jan. 24, 2012, thediscoverblog.com/2012/01/24/a-behind-the-scenes-look-at-lac-the-nitrate-film-preservation-facility/

[115] LAC, "The Preservation Centre," bac-lac.gc.ca/eng/news/videos/Pages/preservation.aspx

for creating 35mm elements from 9.5mm and 28mm films which cannot be scanned. They also operate a wet-lab with two black-and-white processing machines but are not equipped for color processing due to environmental regulations. When color development is needed, it is outsourced to a commercial lab, Mels Studios, in Canada. The LAC switched to using polyester for preservation in mid-1990s and they have always used Kodak film stocks. Despite their plans to move fully towards digitization, the lab still retains the ability to duplicate Regular 8mm, Super 8mm, 9.5mm, 16mm, 28mm and 35mm photochemically.

Filmoteca de la Universidad Nacional Autónoma de México – Mexico City, Mexico

Established in 1960, Filmoteca de la Universidad Nacional Autónoma de México (UNAM) operates as the national film archive of Mexico. UNAM installed an in-house film lab in 1982 and still operates this preservation lab.[116] Prior to 2014, UNAM primarily used older machinery donated by other labs. This posed challenges since parts broke and finding spares or repairing in-house was difficult. But since 2014, UNAM has improved their photochemical lab machinery by acquiring additional printers, developers, and other analog equipment; this in turn has increased the quality of their film preservation work. Acquiring these machines has also made it easier for them to repair and replace parts as they are newer and spare parts are more readily available. Unlike the LAC in Canada which started winding down their photochemical preservation work with the purchase of a new scanner in 2013, UNAM has increased its photochemical throughput and capabilities since 2014 and has no plans to stop this work. Second

[116] Albino Alvarez Gomez, email message to author, Mar. 2018. All information about UNAM gathered from Alvarez, General Director of Cinematographic Activities at UNAM.

only to NAVCC, UNAM is likely the most active and best-equipped analog film preservation lab in North America.

The director of the lab, Albino Alvarez, believes that film should be preserved on its original format for as long as possible and that UNAM also preserves film on film due to the polyester's ability to last as long as 200 years when stored properly. UNAM works extensively in duplicating deteriorating nitrate and acetate elements photochemically. Alvarez maintains that the lab has not had any major film stock or equipment concerns that have negatively affected their film-to-film preservation work. After the creation of new film elements, these are digitized for providing access to the public and researchers, as UNAM considers increasing access another primary responsibility. Alvarez contends that "new technologies have also had much to contribute in terms of preservation, ideally, both formats can work together and one does not substitute the other."

The lab is currently capable of black-and-white processing using two Houston brand developing machines, one for 16mm and for 35mm, in addition to a Debrie 35mm processing machine. They process both positive and negative, 16mm and 35mm elements. They are not equipped for in-house color processing and outsource such work, but they can print both color and black-and-white elements in-house using a wide-range of printers: a BHP wet-gate contact printer for 35mm, a BHP dry printer for 35mm, a Bell and Howell contact printer for 16mm, and two optical printers with the capability of blowing up 9.5mm and 16mm to 35mm. In addition to 5 printers and 3 processing machines, they are equipped with a Lipsner Smith film cleaner, an HFC color analyzer, and a silver recovery unit. The latter is a device that retrieves and accumulates the excess silver from a developing run so that the valuable metal is not wasted. Other labs, such as Kodak Film Lab New York, also use this method and sell the silver gathered

through this process. UNAM does not have an in-house film-out machine and contracts this work out to commercial vendors when required.

UNAM uses both ORWO and Kodak, 16mm and 35mm film stock for their preservation work. They keep a supply of film stored in their refrigerator, not because of discontinuation concerns, but due to long delivery times stemming from low demand. Alvarez notes that in some cases, the films are not manufactured until they are requested. UNAM confirms that they store and utilize the following film stocks for their preservation work:

- Kodak Panchromatic Duplicating Negative 2234/3234 (35mm/16mm)
- Kodak Fine Grain Duplicating Positive 2366 (35mm)
- Kodak Print Film 2302 (35mm)
- Kodak Print Film 7302 (16mm acetate)[117]
- ORWO Panchromatic Duplicating Negative DN21 (35mm)
- ORWO Fine Grain Duplicating Positive DP31 (35mm)
- ORWO Print Film PF2 (35mm/16mm)

Cinemateca Brasileira – São Paulo, Brazil

The Cinemateca Brasileira is one of FIAF's 89 active members. Photochemical film preservation work at the Cinemateca was initially outsourced to commercial labs. But in the late-1970s the Cinemateca's dissatisfaction with the ability of commercial vendors to carry out the specialized work of archival film preservation prompted them to establish an in-house lab for

[117] Kodak discontinued the manufacture of acetate black-and-white print film in 2015 and today only offers polyester black-and-white print film. It is unclear what use UNAM has for acetate print film, but they still hold a cache of this stock.

such work.[118]According to their website the film lab is still operational. But according to two different sources, including Rafael de Luna of Federal Fluminense University who is involved in film preservation in Brazil, the Cinemateca has been facing a serious crisis stemming from dramatic staff reduction over the past few years. While it remains uncertain if the laboratory is currently active, de Luna maintains that it was closed for a long period in the last few months. An attempt to establish contact with staff at the Cinemateca through email was initially successful and they seemed willing to engage in a conversation regarding their lab's current activity. However, no response has yet been received since questions were posed. Further attempts to contact the Cinemateca laboratory have not been successful.

The status of the only possibly active in-house preservation lab in South America remains unknown, although their website makes their commitment to photochemical film preservation processes clear. This dedication to maintain a lab for preservation is explained as stemming from the mass closure of commercial film labs in the region and the increasing necessity for archives to perform this kind of specialized work themselves. A quote form their website clearly illustrates this point: "the advent of digital production and the digitization of exhibition continues to force the closure of commercial laboratories around the world, making it more necessary for the operation of film laboratories within preservation institutions."[119]

Cinemateca Portuguesa: Arquivó Nacional das Imagens em Movimento – Lisbon, Portugal

The national cinematheque of Portugal was originally founded in 1948 and the organization became a FIAF member in 1956. In 1980, the facility was renamed Cinemateca

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[118] Cinemateca Brasileira, cinemateca.gov.br/pagina/preservacao-audiovisual

[119] Cinemateca Brasileira, "Audiovisual Preservation," cinemateca.gov.br/pagina/preservacao-audiovisual

Portuguesa and authorized by the government to be the official moving image archive of the country. The conservation center of the Cinemateca is located outside of the capital Lisbon and is known as the Arquivó Nacional das Imagens em Movimento or ANIM. ANIM remains dedicated to the preservation of film on film, and akin to other film archives with this ideology, maintains an active, analog film laboratory in house for such purposes. Jan-Christopher Horak, who visited the lab in March 2018, documented his visit in a blog post in which he includes detail about the film lab at ANIM, noting that they maintain "one of the last fully functioning analog film laboratories in Europe [which] includes optical printers that can handle significant nitrate shrinkage, two contact printers, a 16mm printer."[120] He also notes that ANIM has an Arrilaser film-out machine for output of digital files to film. According to Horak, ANIM is trying to attract commercial film preservation work in order to support staffing levels necessary to run the facility.

The Cinemateca's website also devotes a page to the film lab, noting that they have maintained a restoration laboratory since 1998. Some of the text on their website reads like a manifesto on keeping photochemical film preservation practices alive in the digital age. They note that the aim of the preservation lab is to preserve film on its original format and that the laboratory is specialized in analog processes which compete in terms of quality with the best international laboratories. Despite the transition to digital, the laboratory has invested in analog technology, "preserving so-called 'obsolete' knowledge and techniques and continuing to offer services that the industry has practically abandoned."[121]

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[120] Jan-Christopher Horak, "A Visit to the Cinemateca Portuguesa," UCLA Film and TV Archive Blog: Archival Spaces, March 15, 2018, cinema.ucla.edu/blogs/archival-spaces/2018/03/16/cinemateca-portuguesa

[121] Cinemateca Portuguesa, "The Laboratory," cinemateca.pt/Servicos/Acesso-Arquivo-Filmico/Laboratorio.aspx. Translated from Portuguese using Google Translate.

Despite the existence of the equipment, facility, and ideological dedication to photochemical film preservation, Horak notes that funding and staffing shortages have negatively affected the amount of preservation work that ANIM is able to do. It is also noteworthy that the master list does not include any other labs in Portugal, leaving ANIM as the only active lab in the country.

Swedish Film Institute – Stockholm, Sweden

Film-to-film preservation at the Swedish Film Institute (SFI) started in the mid-1960s when nitrate originals started being duplicated onto acetate stock. Until 2011, this work was outsourced to commercial labs in Sweden. In the beginning the focus was on preserving fiction feature-length films, but from around 1980 the SFI began preserving nitrate short and non-fiction films as well. In the mid-1990s they started the creation of new preservation and exhibition elements of acetate color films shot between 1950 and 1970. In 2011, when Nordisk Film Post Production, the last full-service photochemical lab in Sweden closed, the SFI decided to set up its own film lab which started operations in late 2012. This lab is still active and used for film-to-film preservation. Through email exchanges with Jon Wengström, Curator of Archival Film Collections at SFI, details of their lab work are gathered and shared here. Wengström notes "We believe that films should be preserved on their original format, and we like to have at least two analogue elements before doing any kind of digitization." [122]

Today the lab's photochemical work is focused on preserving nitrate films that have not yet been duplicated onto more stable film stock. These include a collection of early world cinema (up to 1910) and another collection of Swedish non-fiction film (up to 1950). For films only

[122] Jon Wengström, email messages to author, Nov. 2016 and Mar. 2018.

existing on nitrate, they prefer to go through a fully analog preservation workflow and create new polyester elements. Since the advent of digital scanning, the lab rarely strikes new prints or does film-to-film preservation of acetate elements. These are instead digitized in-house using SFI's digital lab which has been active since 2013. On average the SFI preserves 30 films completely photochemically each year (many of which are shorts), and about 90 films completely digitally. The latter category consists mainly of feature-length films which are sometimes already preserved on film.

When asked about the decision to open up their own preservation film lab in 2012 when so many labs around the world were closing and the switch to digital cinema projection was in full swing, Wengström explained:

> We had been working with [Nordisk Film Post Production and their previous incarnation FilmTeknik] for many, many years. When Nordisk closed, we acquired some of their equipment, and hired three of their most experienced staff. The reason why we wanted to go on doing analogue preservation is that for nitrate films we prefer to have analogue preservation elements before doing any kind of digitization, and we want to be able not only to preserve in analogue but also produce viewing copies in original format (specially valid for silent films due to the lack of alternative frame rate standards in digital projectors). Once making that decision, we could either find a new commercial provider of services abroad, or to set up our own facility. We opted for the latter for many different reasons, not least financial.[123]

[123] Jon Wengström, email message to author, Mar. 2018.

Echoing other preservation labs around the globe, the lab has not noticed any major difficulties with acquiring film stock supplies apart from the fact that it has become more expensive to acquire them. Over the years, the archive has used predominantly Kodak films except for 16mm black-and-white work for which they use ORWO.

SFI's lab is capable of optical and contact printing (both continuous and step, dry and wet-gate). In addition to various other printing actions, they can create composite prints from picture and sound negative elements. They also do in-house processing of 16mm and 35mm black-and-white negative and positive film. While they also develop 16mm and 35mm color print film, they are not equipped for processing color negative film in-house and outsource this work–likely to Focus Film which is the only remaining color negative processing facility in Sweden.

The training of new employees and the transfer of analog film preservation knowledge is a top priority for the SFI, especially when it comes to contact and optical printing. The in-house preservation lab at the Swedish Film Institute provides a model for archives to continue analog film preservation work in the face of decreasing commercial lab services. Along with several other archives, the SFI has embraced this model of establishing an in-house preservation lab when commercial labs traditionally relied on for preservation are endangered.

Thai Film Archive – Salaya, Thailand

The national film archive of Thailand was established in 1984 under the country's Fine Arts Department and became a Public Organization with its own independent funding in 2009.[124]

[124] Chalida Uabumrungjit, interview with author, May 2018. Information about the Thai Film Archive in this section was gathered from staff member Chalida Uabumrungjit.

The Thai Film Archive's (TFA) mission includes collecting and storing film and "their primary commitment is to preserve the materials in their care." To do so, they have operated an in-house film preservation lab since the mid-1980s. Through an interview with Chalida Uabumrungjit of the Thai Film Archive more detailed information about the lab's history and current status was gathered.

Shortly after the film archive's inauguration in 1984, a black-and-white printing and processing lab was set up with equipment donated by the Swedish Film Institute. The black-and-white lab's capabilities include both 16mm and 35mm, step and continuous printing, as well as processing. Because commercial labs in Thailand at that time did not do black-and-white work, and the archive had a collection of nitrate negatives to migrate to safety stock, establishing an in-house lab was the ideal solution. In the beginning, the film archive was underfunded, and the lab only made one safety preservation element from their nitrate elements. In 1998, TFA relocated from Bangkok to their present location in Salaya, about 20 miles outside of Bangkok. From 1998 to about 2015 the lab was active in Salaya, until the construction of a new facility meant they had to temporarily suspend lab operations. The new building is now finished and includes a dedicated space for the old black-and-white lab which they are in the processing of reinstalling in the new facility. In addition, the archive has recently acquired color film lab equipment which they also plan to install in the new facility, making the archive capable of color film printing and processing for the first time since its establishment in the 1984.

The color processing and printing equipment came from the commercial Thai film lab G2D, which recently suspended photochemical operations but continues digital post-production work. Before G2D ended their photochemical work, the TFA utilized their color lab to strike new prints of about 40 films in their collection. This was done as a way to keep G2D's lab open

since the archive was one of their few clients for photochemical work. Before shutting down its photochemical lab and giving the equipment to TFA, G2D created new prints from original negatives of 1970s and 1980s films which the TFA had never preserved. This was made possible due to the archive's restructuring within the government in 2009 which allowed them a higher budget for film preservation work.

Uabumrungjit notes that it will take some time for TFA to install and run the new color lab. Knowing that G2D's color equipment was going to be installed at TFA for preservation use, TFA staff were trained in color film printing and processing at G2D before the suspension of photochemical work. TFA will start to install their lab and perform initial tests in May 2018, with the goal to see results by the end of the year. The lab will have four employees working on photochemical film preservation.

As evidenced by their efforts to reinstall their long-active black-and-white lab, and add a color lab to their new facilities, the TFA remains dedicated to photochemical methods of film preservation. This is partly due to a desire to preserve film on film, but also because they seek to preserve the technology of film production, printing, processing, and projection. Uabumrungjit mentions that while digital technology is useful for many aspects of film preservation, photochemical workflows are inherently different and merit preservation for this reason. TFA holds over 1500 original negatives and have not yet created prints or new elements from many of them. If film stock can be obtained and the film lab remains operational, they seek to create new prints to enable film projection for the public well into the future.

Oleksandr Dovzhenko National Center – Kiev, Ukraine

The Oleksandr Dovzhenko National Center (ODNC) in Kiev, Ukraine, is a FIAF member and according to their website, the largest Ukrainian State Film Archive. The ODNC was founded in 1994 and is also the legal repository for "all the negative prints of Ukrainian films created with public funds."[125] The center purports to have the only Ukrainian cinematographic lab, but the master list names three other commercial film labs in Ukraine. Comments such as these highlight the common theme of misinformation about the existence of film labs; even a national film archive is not necessarily fully informed of the film lab landscape in their country. The commercial labs section of this research (see Appendices) includes more detailed information about these commercial labs.

According to Stas Menzelevskyi, Head of Research and Programming Department at ODNC, the center does indeed have an active film lab that still engages in printing negative and positive copies.[126] For further questions Menzelevskyi suggested consulting the ONDC's website which includes an extensive section on the film laboratory. According to the website "The film-production laboratory is equipped with equipment for contact copying of films […] as well as for the production of film copies (including Intermediates.)"[127] The lab seems to be equipped with both color and black-and-white, 16mm and 35mm, printing and processing capabilities. Several clues on the website, such as a price list, seem to indicate that the lab is not only used for preservation of the film collection, but also for outside commercial projects. In fact, the language and setup of the film lab section of the website, although including a section on restoration, does not explicitly reference the goal as being preservation. Requests for further information about the

[125] ODNC, "About the Centre," dovzhenkocentre.org/eng/about/
[126] Email message to author, Apr. 2018
[127] ODNC, "About the Film Laboratory,"dovzhenkocentre.org/eng/about-lab/

lab's mission and extent of present day preservation activity were not successful. However, according to Stas Menzelevskyi, it can be confirmed that the ODNC in Ukraine maintains an active film laboratory.

Archives New Zealand – Wellington, New Zealand

Archives New Zealand (ANZ) started film-to-film preservation work about 10 years ago.[128] This work was initially done through a commercial post-production facility. When this facility which operated New Zealand's last film lab stopped processing in 2013, ANZ decided to move the lab's equipment to its own building. ANZ had the lab operational by May 2015 and staff members have been preserving film by copying original acetate and nitrate elements to polyester film stock ever since. ANZ's website mentions that "polyester is an extremely stable plastic which has a projected life of 500+ years. Producing such film copies ensures their long-term survival, and financially compares favourably to the costs of preservation-level digitisation." Archives New Zealand is an example of a film archive continuing analog preservation because they have found it more affordable than what they refer to as preservation-level digitization.

Through direct communication with ANZ, it was confirmed that they still maintain an in-house photochemical film lab. Nina Kurzmann, Team Leader at the Film Preservation Laboratory notes that "the lab is still active as we have not yet completed our preservation program." This project involves the preservation of the National Film Unit (NFU) collection

[128] Nina Kurzmann, email messages to author, Apr. 2018. Information about ANZ's current lab operations from Team Leader of Film Preservation Laboratory Nina Kurzmann.

Kurzmann notes "represents a very important part of New Zealand's history and culture." ANZ may continue preserving other collections on film once this project is complete.

Their small in-house film laboratory is used for duplicating master film elements to polyester film stock but is not capable of striking composite prints. Newly created polyester elements are intermediates for long-term preservation and not suitable for access and exhibition. The lab is capable of timing, cleaning, and printing to create an intermediate element, such as an interpositive or internegative, depending on the source material. They can also develop this new element. Because their goal is "1:1 copies" they do not do any optical reduction or blow-up. If their starting element is on acetate film, they utilize a Schmitzer wet-gate contact printer and for nitrate elements they use a Debrie step contact printer. The preserve a variety of film formats, including negative originals, prints, and reversal elements, in both 16mm and 35mm, color and black-and white. For access, the archive offers telecine transfers on demand which are usually made from prints to avoid handling original negatives. Negatives are occasionally scanned for high-end usage such as incorporation into documentaries but ANZ does not currently have a digitization program in place.

China Film Archive – Xi'an Province, China

China Film Archive (CFA) has a film vault for positive prints in Beijing, and a negative vault in the city of Xi'an. The Xi'an facility also includes an in-house film lab set up with processing and printing facilities "for film preservation and duplication."[129] Requests for further information on the lab's capabilities, history, and extent of current activity were received too late

[129]Liu Wenning, email message to author, Apr. 2018.

to be fully incorporated into this paper, but it can be confirmed that the CFA still maintains an active photochemical film laboratory engaging in film-to-film preservation.

National Library of Norway – Mo i Rana, Norway

According to Lars Gaustad, Head of Digital Library Development for Film, at the National Library of Norway (NLN), the library still maintains an active in-house film preservation lab.[130] The lab was established in 1992 and since then they have almost completed the preservation of all Norwegian feature-length films for which they hold negative material. There remain only six black-and-white films to preserve, in addition to many shorts and non-fiction films from the nitrate era. According NLN, no other film labs remain active in Norway today.

The lab is capable of black-and-white processing of negative and positive 35mm film; the lab does not work in 16mm. They also develop 35mm color print film but not color negative film. The lab uses Bell & Howell printers and only Kodak stock. They have not yet run into any issues stemming from a decline film stock manufacturing. The shift towards digitization has affected the analog film preservation work of the library and today analog work is only done if the starting element is a 35mm negative. All 16mm elements and all positive elements regardless of gauge are preserved through digital workflows.

Part of the reason that NLN still continues analog preservation of film is to "get as much preservation work done as possible," by combining analog and digital methods; they do not consider their digital scanning throughput to be sufficient to preserve everything that they have deemed necessary to preserve in time. Therefore, a combination of analog and digital

[130] Email message to author, Apr. 2018.

preservation work is used to increase throughput, increasing the likelihood that more films will survive. As is the case with many of the responses to this survey, different labs present different reasons for their continuation of analog film preservation work.

British Film Institute – London, UK

One of the founding members of FIAF, the BFI's film preservation work up to 1994 is chronicled by Penelope Houston in her book *Keepers of the Frame: The Film Archives*. The BFI National Archive website alludes to making prints and copying deteriorated film for preservation and access but remains ambiguous about the methods employed. The BFI's collection policy document also includes a section on copying and migration which mentions preserving the originals as the main goal and notes that when duplication is necessary it will be on the original format unless otherwise prohibited. Multiple inquires to the BFI regarding the current state of their photochemical film preservation work have gone completely unanswered.

Korean Film Archive – Paju, South Korea

The Korean Film Archive (KFA) in South Korea is a FIAF Member organization. This is the only active in-house preservation lab not mentioned on the master list, likely due to its recent establishment in 2016. According to their website, in 2016 KFA opened a new preservation facility equipped with a photochemical film preservation lab in the city of Paju:

> The Paju Preservation Center is a facility that opened in 2016 to perform preservation and restoration work for the Korean Film Archive. Using this dual preservation system in addition to the preservation headquarters in Sangam, disasters are thoroughly prevented. As it is equipped with various high-tech

> preservation and research facilities such as film development and printing facilities and a 4K-based film digitalization and restoration system, the Paju Preservation Center makes efforts for the transmission of Korean image culture heritage to descendants.[131]

Chalida Uabumrungjit from the Thai Film Archive confirms that KFA has an active photochemical lab which she visited in 2017. She notes that the lab has many staff members and is capable of color and black-and-white film preservation with equipment gathered from a defunct commercial lab.[132]

Gosfilmofond – Moscow, Russia

Gosfilmofond is the Russian government's well-known state film archive and a member of FIAF. Although neither FIAF, IU, or AMIA list the lab in their directories, Kodak does. While Gosfilmofond's website has some information about their film preservation activities, it does not make explicit the existence of an active in-house photochemical lab. Under their "Services" section it is noted that the archive is capable of "replication, reproduction and translation of films and videos on various types of media, including the original film materials for 16, 35, 65, 70-mm film with high shrinkage."[133] Attempts to contact the archive to inquire about the current state of their photochemical preservation work were not successful and it cannot be confirmed whether Gosfilmofond currently engages in film-to-film preservation work.

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[131] KFA, "Paju," eng.koreafilm.or.kr/pages/PC_00000111
[132] Interview with author, May 2018.
[133] Gosfilmofond, "Services," gosfilmofond.ru/?page_id=5217&lang=en

Arhiva Nationala de Filme: Cinemateca Romania – Bucharest, Romania

The Romanian national film archive is a FIAF member and their website indicates that they maintain full photochemical capabilities for preservation and access.[134] The extent of the lab's current activities could not be confirmed through this research as attempts to contact the archive for further information via email were unsuccessful.

Archives Françaises du Film du Centre National de la Cinematograph – Paris, France

The CNC is the national film archive of France and along with Cinémathèque Française, one of the two FIAF members in the country. Although the CNC's website makes allusions to both photochemical and digital restoration work, the presence of an in-house film lab is not explicitly stated. The CNC did not reply to requests for information on their current photochemical preservation work and it cannot be confirmed that they currently operate an in-house lab.

According to Rachael Stoeltje, the CNC still requires film deposits of French productions, even for born-digital content.[135] In addition Jon Wengström, in an April 2017 article in *The Journal of Film Preservation* notes that "some archive colleagues still require the deposit of film elements on film for born-digital productions."[136] While Wengström is not referring directly to CNC, his statement, when combined with Stoeltje's, makes it seem likely that this is indeed CNC's current practice for archiving born-digital film. While the archive itself could not

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[134] ANF, "Services and Tariffs," anf-cinemateca.ro/servicii-si-tarife
[135] Interview with author, Mar. 2018.
[136] Jon Wengström, "The Coexistence of Analogue and Digital Strategies in the Archival Film Collections of the Swedish Film Institute," *Journal of Film Preservation*, no 97 (April 2017): 64.

be reached for comment, it is significant for the film archiving and preservation field that a prominent country in cinema culture such as France still maintains this requirement in 2018.

Bundesarchiv – Berlin, Germany

The Bundesarchiv is the official archive of the German government. Within the Bundesarchiv exists the Filmarchiv which comprises the national film archive of Germany and holds 154,000 film titles and employs about 100 people.[137] An active FIAF member, the film archive claims to be one of the largest in the world. According to Martin Koerber of the Deutsche Kinemathek, the Bundesarchiv still maintains an in-house lab capable of black-and-white processing, and printing in color and black-and-white. Color film development cannot be done in-house and is contracted out to commercial labs when needed. Koerber goes on to note, "the plan is to shut down photochemical procedures at some point in the future and go fully digital in terms of duplication."[138] Several attempts to contact the Bundesarchiv directly for information about the current state of their film lab operations were unsuccessful but Koerber's information is sufficient to confirm the presence of an active photochemical preservation lab at the Bundesarchiv.

Kazakhfilm Studio – Almaty, Kazakhstan

Kazakhfilm Studio (KFS) is both a state-run production studio and the national film archive of Kazakhstan. According to staff member Dimitry Shishkin, the parliament in Kazakhstan is considering a "bill 'On Cinematography' – [and] when it is accepted, the film

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[137] Bundesarchiv, "Films," bundesarchiv.de/EN/Navigation/Use/Hinweise-zur-Benutzung/Filme/filme-en.html

[138] Email message to author, Apr. 2018.

archive will be a separate state structure, and [Kazakhfilm] will remain only a studio."[139] This implies that the new law would separate the film archive from the production studio if it is adopted. Shishkin also notes that although KFS does have a film lab, they have been shooting on digital in recent years and the laboratory is "mothballed." However, the lab is still occassionaly used for what they refer to as the reverse process, to store digital productions on film by recording them out with an Arrilaser. Today, the lab is very rarely used for photochemically duplicating archive films for preservation or restoration.

Their website also indicates that they had visitors to a new film laboratory in 2012.[140] An older version of their website is still active, with a section entitled "Film Processing" which indicates full range of photochemical processes including "Development of a black and white negative" and printing of black-and-white and color positives. A newer website does not indicate any analog film abilities. Overall, the film lab at KFS seems to only be active in creating archival film elements of current born-digital productions and not utilized to preserve works from the national film archive.

Imperial War Museum – London, UK

Although listed as an active lab by both FIAF and IU, it can be confirmed through direct contact with David Walsh that the IWM has ceased all film-to-film preservation activities despite its long and fascinating history in this field. The early years of IWM's preservation work have already been profiled in this paper. This work continued with the IWM photochemically

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[139] Dimitry Shishkin, email messages to author, Apr., 2018. Information on Kazakhfilm Studios gathered from staff member Dimitry Shishkin.

[140] Kazakhfilm Studios, Press Release, 2012, kazakhfilmstudios.kz/en/press/news/6915/?sphrase_id=98776

duplicating their WWII-era nitrate film onto acetate stock until the late-1990s. In 2000 their target film stock was switched to polyester and this activity continued until their sole remaining lab operator–responsible for both printing and timing–retired in 2012. At this point the decision was made to cease photochemical activity instead of hiring and training new staff. Walsh also notes that by this time almost all their WWI and WWII nitrate footage had already been duplicated onto acetate or polyester stock and the museum's preservation strategy had shifted to storage of the originals in cold storage and digital scanning for access. Film stock decline was not a major problem for the museum since they stopped using film before the major discontinuations.[141]

While the museum never did any in-house film development, they were equipped with in-house printing. Their printing capabilities included continuous and step contact printing of black-and-white 35mm and occasionally 16mm film. Black-and-white processing was outsourced to a commercial lab called Prestech, which was "set up by an expert in archive film printing which suddenly ceased trading three or four years ago."[142] Henderson and Rank laboratories provided processing services to the museum prior to Prestech, and both of those labs also shut down some time ago. All color processing and printing work was also contracted to commercial labs.

Cinematheque Royale de Belgique – Brussels, Belgium

A FIAF member from the earliest days of the organization's founding, the national film archive of Belgium (CRB) was established in 1938. They operated an analog film lab since the 1970s because it was easier to do film preservation work in-house. Through an interview with

[141] David Walsh, email messages to author, Feb. 2018.
[142] Ibid.

Arianna Turci, who is in charge of access to film collections at CRB, it was confirmed that they have not done printing or processing work since the early-2000s when their in-house lab suspended photochemical operations.[143] Today, CRB does all their preservation and restoration work through digital scanning and no film elements are created because they do not have the funds to go back to film. Turci agrees that it would be ideal to create film elements for film restoration projects, but their limited public funding does not allow for this. She goes on to note that it is very expensive to preserve film as digital files as well because of the multiple copies required, the expense of LTO tape, server maintenance, and future migration.

The archive has not done film-to-film for many years but all their nitrate material had already been copied to acetate when they suspended lab work in 2000. These duplicate acetate elements have proven useful for their current digitization workflows since in some cases the original nitrate elements have deteriorated. When the film lab was open from the 1970s to the early-2000s they were capable of black-and-white and color printing and processing of 16mm and 35mm film. The lab used both optical and contact printers and Kodak, Agfa, and ORWO film stock. The lab was used only for in-house preservation work and never for outside clients or contemporary productions.

National Film and Sound Australia – Canberra, Australia

Attempts to gather information on the current state of film-to-film preservation work at the NFSA led to a brief statement by Janine Walkom, Senior Manager of Digital and Media Operations, which is replicated here in its entirety:

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[143] Arianna Turci, interview with author, Apr. 2018. All information about the CRB gathered during this interview.

> The NFSA has preserved 16 & 35mm black and white motion picture film photo mechanically since 1989. We have gradually changed our systems over the years to include digital scanning. However, we are in the process of closing down our motion picture photo mechanical facilities, as obtaining readily available engineering support and parts was becoming difficult.[144]

No further information on this decision was shared by the NFSA. This confirms that the NFSA will no longer be an active photochemical preservation lab.

The NFSA's digital restoration projects in partnership with Haghefilm Digitaal in Amsterdam take center stage on their website. This digital restoration program is dubbed NFSA Restores and was launched in October 2015. According to the NFSA "the program uses the best available original picture and sound components to create digitally restored masters for preservation purposes, and digital cinema prints for screening."[145] Regarding the switch from analog to digital preservation, the NFSA notes:

> Over a period of 10 years from 2000 to 2011, new film prints were produced through our Kodak/Atlab and Deluxe/Kodak photochemical programs. The result was the restoration of 75 iconic titles that have since enjoyed a rejuvenated appreciation by a new generation of admiring audiences.
>
> In the digital world in which we now live, digital film restoration was the next logical step.[146]

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[144] Janine Walkom, email communication with author, March 27, 2018.
[145] NFSA, "Preserving the Collection," nfsa.gov.au/purpose-2-preserving-collection
[146] Ibid.

Silesia Film Institute – Katowice, Poland

An associate member of FIAF, the Silesia Film Institute functions as the regional film archive of the Silesia province in Poland. In addition to the Silesia Film Archive, the institute is active in funding film production and exhibiting film in cinemas across Poland. Although their website mentions a devotion to motion-picture film, its care, and preservation, there is no explicit mention of a film lab or duplication of film. The landing page displays the following text: "we moisten, clean and preserve [our celluloid film]. We store gems of the Polish and world cinematography in our archives, wipe dust off of them and give them new lives."[147] An attempt to establish contact the film archive through email addresses listed on their contact page has not been successful. Although the lab is listed as active by both FIAF and IU list, this research has not been able to confirm its current status.

National Film Archives of Iran – Tehran, Iran

The National Film Archives of Iran (NFAI) is a FIAF member and listed as having a lab on both the FIAF and IU lab directories. My attempts to reach the NFAI through contact information listed publicly on FIAF's website have so far been unsuccessful. In a 1991 *Journal of Film Preservation* news blurb, the NFAI noted that they were undertaking the "building a new cultural centre to comprise all the facilities of the archive including film, video storage rooms, library, screenings and laboratory facilities."[148] These new facilities were set to be completed by 1995.

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[147] Silesia Film Institute, silesiafilm.com/en/

[148] M.H. Khoshneviss and Fereydoun Khameneipour, "Tehran: National Film Archive of Iran," *Journal of Film Preservation* 24, no. 51 (Nov 1995): 39.

According to a long-time film colorist and restorationist in Iran, "the only semi-active" lab in the country today is that of the government's official TV and radio broadcasting company (IRIB) which is different from the NFAI. She notes that IRIB is collaborating with the NFAI to wash and prepare negatives or prints for digitization. It is unclear whether even the IRIB does any actual film printing or processing. The two other photochemical labs, The Iran Centre for Film Industries and Filmsaz Lab, closed about two years ago.[149] While this information is not first-hand confirmation from the NFAI, it is implied that the archive no longer has an active lab. Despite this, there are indications that the archive is active in digital scanning and restoration of their film holdings.[150]

Korean Film Council – South Korea

Although the Korean Film Council (KOFIC) is listed on both the FIAF and IU lists, there is no indication of photochemical film lab or preservation activities on KOFIC's website. Attempts to contact KOFIC for information were not successful and the existence of an active film lab can be neither confirmed nor denied. As mentioned previously, the Korean Film Archive–a different institution which is not included in any of the film lab lists–does have an active and newly constructed preservation center and active film lab in Paju, South Korea.

[149] Iranian film colorist and restorationist, messages to author, May 2018.
[150] Tom Vick, "Reseeing Iran: Our 20th Iranian Film Festival," Jan. 8, 2016, freersackler.si.edu/reseeing-iran/

Vietnam Film Institute – Hanoi, Vietnam

The national film archive of Vietnam is a member of FIAF and listed by FIAF, IU, and AMIA as having a photochemical film lab. Attempts to contact the Vietnam Film Institute directly or to gather information about their lab through SEAPAVAA were not fruitful.

Government Film Unit – Colombo, Sri Lanka

Although not a FIAF member or associate, the Government Film Unit (GFU) of Sri Lanka is mentioned in both FIAF and IU lists as having a film lab. Attempts to reach the GFU through email addresses listed on their website were not successful. Sri Lanka does have a film archive associated with FIAF, The National Film Corporation of Sri Lanka, but this institution is separate from the GFU and not listed as having a film lab on any of the lists.

Conclusion

One of the biggest questions facing the film preservation community is whether digitizing films as a preservation strategy without creating new film elements is an adequate method of preserving the cultural and historical motion picture film objects in the care of memory institutions. Will the next generation of film preservationists consider photochemical preservation as an avenue for preserving their film collections or will digitization be the only available option? Can digital scans of a film strip fulfill the same function as new film preservation elements? How does this trend of film digitization-as-preservation compare to other conservation disciplines and the way that they view preservation? Is the knowledge and practice of photochemical film preservation already presumed no longer worthy of pursuit by those who are to become the future stewards of film collections? Have institutions with unique film collections decided that the only way to preserve and make their films accessible is to digitize them and provide access to the digital files? When did this massive shift in goals occur and why did the field decide that photochemical duplication of film is cost-prohibitive and that it is too difficult to show prints regularly?

As is demonstrated in this writing, preserving film on its original medium remains a viable and widely practiced preservation strategy worldwide. Especially now that the film stocks are vastly improved over the historical options; the photochemical processes are more exacting and clean; the lab technicians are ever more conscious of the importance of archival work; and the exhibitors are mindful of how to fully display the unique qualities of film prints and put on a show in theatrical spaces, it can be argued that film-to-film preservation is an excellent method of preserving films.

One possible solution to balance the digital and photochemical preservation methods is to reposition digitization strategies. As pointed out by filmmaker and preservationist Andrew Lampert, digital tools can be useful for digitizing orphan films with no official support and have increased access to such films exponentially.[151] Despite this, film archives can still continue photochemical film preservation of the so-called 'gems' of the archives, creating new polyester elements and prints from their high priority nitrate and acetate films. Fundraising for the preservation on film of these films does not preclude digitization to broaden access to the parts of the collection unlikely to be preserved photochemically: incomplete works, outtakes, home movies, the categories of film which are either less bound to the format of film or not meant for exhibition on film at all.

Although it is taken for granted by some that easy access to digital infrastructures, digitization and digital preservation is more efficient or cost-effective than the creation of new film elements, this is not true of all archives. Enabling the preservation of film on its original format for the foreseeable future is an enormous challenge, and while funding and the passing of specialized skills to the next generation are true impediments, they should not stop the film preservation community from striving to keep analog film preservation alive as an option to preserve film.

Although fundraising is a constant challenge for cultural heritage and memory institutions, both the LOC and UCLA FATVA have had state of the art facilities funded and built for them in Culpeper and Santa Clarita, respectively, in the past decade. In addition to funding, staff knowledge and expertise is the next largest challenge facing film-to-film preservation today. By not considering film-to-film preservation as a continually important part of the

[151] Fossati, *From Grain to Pixel*, 168.

education and skill-set of moving image archivists, the community increases the chance for the cessation of these practices. If not continually informed of its changing state, needs, and challenges, analog methods of film preservation may become fully obsolete. However, even if all challenges are met and the film stock, labs, technicians, knowledge, audience and desire exist to continue film-to-film preservation; an attitude that the funds will never become available could help speed this obsolescence in the archival community. This is not to deny the increased difficulty of practicing film-to-film preservation due to lack of funding, but to question whether enough consideration has been given to digital scanning as the de facto preservation of film for modern and progressive archives. Does it truly meet the duties of the archival and preservation community to preserve film objects?

Today, once a film is preserved through the creation of new polyester elements, it will likely never need to undergo another photochemical preservation. The same cannot be said for digital scanning since the technology is evolving annually; the field has witnessed the change from Standard Definition telecines, to HD, 2K, and 4K resolution scanning and beyond. It is safe to assume that film scanning technology will continue to advance. On the horizon are technologies that could digitally capture even more color and density information.[152] Meanwhile, in creating new polyester preservation elements, the film is stabilized on its original medium, and either the original or this new element can be scanned as needed, likely more than once in the future as digitization technology improves.

Despite these arguments, the digitization of motion-picture film is now considered by some archives, such as the Library Archives Canada and the NFSA to be the only feasible method of preserving, restoring, and making films accessible. Others, such as the Swedish Film

[152] Filmic Project, “What is Filmic?” filmic.tech/about-filmic

Institute and Filmoteca UNAM, debate whether digitization of film is a true preservation since the original format is altered. Giovanni Fossati wrote in 2009 in her seminal *From Grain to Pixel*, "the restorer can take his or her pick among available film stocks, printing and processing equipment and, since a decade ago, digital tools in order to simulate as closely as possible archival films that were made with different technologies.[153] A decade after Fossati, the aim of this project was to see how viable and widespread the photochemical restoration and preservation of film is, as even in 2009 the use of digital tools was becoming more widespread. While the future of analog film preservation is by no means bright, it is apparent that the use of analog film preservation and restoration workflows has outlasted most predictions of its demise as it is still practiced by numerous film archives and commercial labs worldwide.

The assumption that digital preservation is the only viable method for future film preservation is hasty; photochemical film preservation not only allows for the continuation of the original medium, which refuses to obsolesce, but also carries the benefits of preserving film on polyester film, largely agreed to be one of the best archival materials. Film stock availability does not yet provide a barrier to achieving analog preservation as is commonly assumed, instead, the biggest challenges are a lack of funding and diminishing expertise in the staff at archives. Both of these can be addressed within the culture of the film archiving community and deserve more thought in the future, to which this writing hopes to contribute.

[153] Fossati, *From Gran to Pixel*, 142