

Quality Control for Media Digitization Projects

Mike Casey, *Media Digitization and Preservation Initiative, Indiana University, USA*

DOI: <https://doi.org/10.35320/ij.v0i50.92>

Abstract

This article defines types of quality control and explores risk management strategies that are broadly applicable to any organization engaged in media digitization for long-term preservation. It uses the quality control system for audio and video digitization that was developed by Indiana University's Media Digitization and Preservation Initiative to provide examples and illustrations of these ideas.

1. Introduction

Everyone makes mistakes. It is endemic to the human condition that perfection can never truly be achieved or, at the very least, sustained. Rest assured that any operation created or guided by human beings will make mistakes.

Media digitization operations are no exception. Even the best vendors and in-house digitization studios make errors that they consider embarrassing. These errors should be rare, and media digitization projects must develop robust quality control and quality assurance systems that provide a reasonable chance of finding or preventing them.

The terms 'quality control' (QC) and 'quality assurance' (QA) are often used interchangeably even though they mean different things. The American Society for Quality defines QC as a *reactive* procedure used to check products for adherence to a defined specification. Key products of media digitization include digital media and metadata files, and QC involves examining them to validate that they meet the digitizing institution's guidelines. Quality assurance, on the other hand, is a *proactive* process that consists of taking steps in advance to ensure that the product *will* meet the specification (ASQ, 2018). For example, in a media digitization operation the QA program may develop guidelines relating to personnel, training, type of equipment used, or other areas that affect the quality of the product.

For the digitizing institution, the quality control function is nearly as important as the act of digitization in the quest for long-term preservation. The institution must perform its due diligence on files submitted for preservation, assessing them for adherence to its specification. It does this best through a QC program that validates the products destined for storage, providing proof that the appropriate pieces are in place for enduring preservation.

Quality assurance is critical for vendors who cannot rely solely on a reactive QC process to identify problems. By the time a problem is identified by QC, it already exists and is impacting the vendor's ability both to perform accurate work and to manage the project's bottom line. Instead, vendors must put in place safeguards that prevent problems from developing. When problems do occur, the vendor may use them to make improvements to the digitization system, as part of a process of continual improvement.

2. Indiana University Context

The present article defines types of quality control and explores risk management strategies that are broadly applicable to any organization engaged in media digitization for long-term preservation. It uses the quality control system for audio and video digitization that

was developed by Indiana University's (IU) Media Digitization and Preservation Initiative (MDPI) to provide examples and illustrations of these ideas.

MDPI is charged with digitally preserving all significant audio and video recordings on all IU campuses in time for the University's Bicentennial in 2020. As of this writing, the project has digitized more than 305,000 recordings in just over three years. The bulk of the digitization is handled by Sony Memnon, the University's private partner, who uses parallel transfer workflows for most, but not all, of this work. Parallel transfer workflows are characterized by the use of one operator to digitize multiple recordings at the same time. For fragile formats and problem items that cannot go through a parallel transfer workflow, IU established a smaller digitization operation—IU Media Digitization Studios (IUMDS)—that utilizes mostly, but not completely, 1:1 workflows where one engineer digitizes one recording at a time.

At peak, Memnon delivers 12 TB of data *per day* from the digitization of more than 600 recordings, yielding over 4,000 digital files. The IU operation generates additional files. All of these are subject to quality control. MDPI resources allow for one full-time QC specialist. Two other staff devote a portion of their week—typically 10-40%—to QC work, and two student hourly workers also contribute to checking files.

3. Types of Quality Control

At the highest level, we recognize two basic QC types: automated (machine-based) and manual (human-intensive). Automated QC is carried out by software tools, while human-intensive QC is a manual process that relies on the human senses of sight and sound as well as on our capacity for logic and reasoning. These may seem like very different strategies, but in truth, the two types of QC make use of each other. For example, human cognition is necessary to interpret the software output of machine-based QC while machines must render the digital files that are analyzed using sight and sound.

3.1 Automated QC

Automated machine-based QC routines may use commercial, open source, and/or home-grown applications. For MDPI, IU developed its own scripts that analyze 100% of the media files produced by the project. This is part of the MDPI post-processing system, and it includes checks in the following areas, among others:

- presence/absence of digital provenance metadata
- presence/absence of specified embedded metadata
- directory and file names
- presence of expected file types (preservation master, production master, etc.) for the format digitized
- format and wrapper
- file extension
- audio stream count
- sample rate, bit depth, codec name, frame rate, pixel format
- duration across streams and across file types

3.2 Human-intensive QC

Human-intensive QC, on the other hand, features an MDPI staff member listening to and/or viewing digital files to judge the accuracy of characteristics that are typically not assessed well by machines. For example, open reel audio tapes recorded in the field occasionally exhibit problems such as reversed audio or changes in speed. Currently, software cannot accurately discover these issues. Nor can software identify cases where the audio or video content and corresponding metadata are mixed up and obviously (and mistakenly) refer to different recordings. One example is where the content does not appear to match the title provided. Also challenging are cases where a metadata value is logical and/or possible, but not correct. In these instances, human senses and cognition are necessary to evaluate for accuracy.

Human-intensive QC may be conducted using the source recording that was digitized, comparing it directly to the resulting digital files. It may also be performed without the source recording, in which case judgments are based on general expectations about the format and its technical characteristics as well as experience in identifying typical problems. We use the term ‘Direct QC’ to refer to the methodology that uses the source, comparing it directly to the digital files produced. This direct comparison is the only way to assess workflow steps that rely upon the judgment and accuracy of the operator. The azimuth adjustment step in an open reel audio tape or audiocassette workflow, for example, is one area in which the operator makes a judgment call as to which setting is the most accurate. The only way to check this choice is to play the digitized recording, comparing it to the corresponding part of the digital file created during digitization to assess its accuracy. Luma adjustments for video digitization—setting black and white levels—also represent judgment calls by the operator when there are no reference color bars and are best evaluated with Direct QC.

While effective, Direct QC requires more resources than a quality control methodology that does not use the source recording. Appropriate playback equipment, knowledge of safe playback procedures, a critical monitoring environment,¹ and additional staff time are essential for successful Direct QC. Employing a methodology that does not use the source recording enables QC staff to examine a larger number of recordings. An ideal QC workflow may make use of both, targeting Direct QC to digitization steps that cannot be adequately evaluated in any other way.

3.2.1. Selection for QC

Project resources allow us to undertake human-intensive QC for approximately 10% of the recordings digitized by the MDPI project. We take a random sample of recordings identified by our tracking/management database for QC staff to tackle. However, to maximize our resources we also employ the following selection strategies:

3.2.1.1. Value-based QC

Directing more QC resources to formats, collections or recordings that are considered of higher value and fewer to those deemed less valuable.

As an illustration, the MDPI project digitized a limited number of commercial LPs and 45s.

¹ Although an audio studio designed as a critical listening room is ideal, Direct QC using headphones is workable.

IU curators told us that, while these were valuable enough to digitize, they were significantly less valuable than other formats. In their estimation, directing fewer QC resources to these formats in order to make available additional resources for in-depth checking of more valuable formats was worth the risk.

3.2.1.2. Risk-based QC

Analyzing digitization workflows and digitized formats to identify where risk is greater and directing more resources to those areas.

For example, we define the time period in which something new is started or something has changed as carrying greater risk. Therefore, when the digitizing operation begins a new format, hires a new person, or begins using a new machine, the QC team will allocate additional resources for a specific period of time to mitigate the risk.

Some formats may be more problematic and require extra QC effort. For instance, U-matic videotapes are actively degrading, resulting in a greater risk that problems such as head clogs from oxide buildup during playback will develop. Solving this problem may necessitate re-digitization.

4. Quality Control as Risk Management

The types of human-intensive QC described above all make use of an evaluation of risk in one form or another. In fact, the entire QC function of a media digitization operation may be conceptualized as an exercise in risk management. Quality control procedures must provide a reasonable level of confidence that the products of digitization meet expectations. However, we already know that human beings make mistakes, and therefore there is a risk that the human-run digitization operation will make mistakes. A useful definition of risk for our purposes is the chance or probability of a loss.

4.1 Risk in Media Digitization

The primary high-level risk for a media digitization operation is that it will produce digital files that do not meet an organization's specification for preservation, and that these 'bad' files will be stored into the future as trusted preservation surrogates. More specifically, there is a risk that the digitization process itself will introduce errors into the files (**loss of accuracy**). There is also a risk that the work will not be done optimally—that we will have 'left something on the table' that results in, generally speaking, audio that could have sounded better or video that could have looked better (**loss of fidelity and accuracy**). Further, there is a risk that errors will be introduced into the metadata that accompanies a recording (**loss of context and interpretability**). Finally, there is a risk that the operation will not digitally preserve an item at all because of a mistake in keeping track of recordings or files (**loss of preservation**).

Let's consider examples of actual problems in each of these categories in turn. First, a loss of accuracy may result from equipment problems such as a malfunctioning time base corrector that produces flashing video frames during digitization of a U-matic tape. This can be corrected by using a different TBC to produce a more accurate digital file. A loss of fidelity may be the consequence of skipping the azimuth adjustment on an open reel audio tape since this may well yield less high frequency content in the digital file than is on the tape. Making the adjustment provides greater (and, hopefully, maximum) fidelity. A classic example of a loss of context and interpretability begins with a digitization operator

neglecting to note that a crack on a cylinder recording resulted in a periodic thump during playback. A researcher hears this sound, misinterprets it, and concludes that the recording includes a drum. Finally, a prep worker notices a potentially serious defect on a recording, sets it aside for later examination, does not enter it into the database, and forgets to note that it was pulled. The recording is effectively lost and is not digitized or preserved.

The impact of these losses on future uses of the target content may be subtle or profound. They can result in researchers using representations of content that are inaccurate or of lower quality than is possible, reaching false conclusions based on misleading or absent metadata, or not discovering content at all because it was not preserved.

These risks can be managed by the QC system in tandem with a robust quality assurance program. Risk management may be defined as “the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events” (Hubbard, 2009, p. 4). Classic risk management thinking identifies four basic areas in which an operation may respond to or treat risks:

1. Transfer the risk
2. Avoid the risk
3. Reduce or mitigate the risk
4. Accept the risk

4.1.1. Transferring Risk

Transferring the risk involves moving responsibility to another entity to minimize or remove the risk to the organization originally carrying it. A typical example is the use of insurance. The insurance company assumes specifically defined financial risks from a policyholder who pays a premium for this service. However, risk transfer may also be employed through a contract that contains an indemnity clause in which one party agrees to be financially responsible for specified liabilities that may be incurred by another party. Within the audio/video part of the MDPI project, some risk is transferred to the digitization vendor through provisions of its contract with IU. The contract stipulates that the vendor is responsible for fixing all problems and re-digitizing as necessary at no cost to MDPI as long as problems are reported within a fixed time period after digitization (40 days for audio and 30 days for video). This provision protects IU from mistakes made by the vendor as long as they are detected promptly.

4.1.2. Avoiding Risk

There are two ways in which an operation can avoid risk altogether: by choosing not to take whatever action exposes it to risk or by employing a resource that removes the risk. Avoiding actions that result in greater risk is often not an option for media digitization operations. For instance, the use of parallel transfer workflows is typically considered to carry greater risk than 1:1 workflows, although this is a complex question that is open to debate. It may not be a reasonable option for institutions with cost and time limitations to use only 1:1 workflows, which result in greater costs and time, to digitize their collections. Specific workflow steps may present similar issues. For example, performing an azimuth adjustment as part of an audio tape digitization workflow adds significant risk—if not done well, the audio will be missing high frequencies. However, this step is essential to obtaining maximum fidelity and accuracy in the digital file and is considered mandatory.

There are, however, some areas in which risk can be avoided. For example, MDPI removes risk by designing QC checks into its post-processing system. All files are handled by post-processing and therefore all are subject to this series of checks. A list of some of the QC checks performed by the post-processing system may be found above in the section on types of quality control. In this way, we remove practically all risk for the variables checked by the system. To illustrate, all audio files are checked for bit depth. Files that are not 24 bit are failed and the original recordings sent back to the vendor for re-digitization. Since computers are quite capable of accurately checking this variable, and every file is checked, there is little risk of not meeting this specification.

4.1.3. Reducing Risk

When risk cannot be avoided altogether, the probability of loss can still be lessened by applying controls or taking particular actions. Even something as fundamental as the timing of QC work can reduce risk. Quality control is most effectively performed soon after digitization. That is because staff currently in place are familiar with the digitization project and possess the skill set and motivation to discover problems. While it may seem reasonable to think that files safely stored can be checked at any time, there is no guarantee that staff in years to come will have the context and ability to perform QC optimally. There is also no guarantee that the vendor will still be in business or willing to help troubleshoot serious issues. Moreover, given the pace of obsolescence for some formats, finding appropriate playback machines may prove difficult in the future.

MDPI has implemented a number of policies, procedures, and programs to reduce the risk that out-of-spec digital files will be placed into preservation storage. First, all fragile formats such as wax cylinders, lacquer discs, wire recordings, and ½" EIAJ videotapes are automatically routed to the 1:1 workflows used by IUMDS rather than the parallel transfer workflows used by the vendor. Successful playback of these formats typically requires the constant attention that is possible when one engineer digitizes one recording at a time. There is the added bonus that recordings in these formats tend to represent some of the highest value content for IU. This policy is more akin to a quality assurance step than a quality control check.

MDPI also implemented a human-intensive QC program to reduce risk. An MDPI staff member listens to or views files from a randomly selected sample of 10% of digitized recordings in order to judge their suitability for preservation storage. Staff use format-based checklists containing specific checkpoints to guide them in this work. This part of the QC operation includes the use of value-based QC, risk-based QC, and Direct QC as described above.

Human-intensive QC takes another form with a regular project team meeting to review the output of cylinder digitization, which is particularly complex. Two audio preservation engineers alternately work on cylinders, producing signal-processed production master files along with unaltered preservation master files. Every two weeks, the cylinder team gathers for a listening session that focuses on work from the previous two weeks. Discussions at the meeting foster consistency between the two engineers as well as confirm the overall quality of the work, reducing risk in this area.

Finally, MDPI has implemented a program to retrospectively select and perform focused QC on files created from some of IU's highest-value recordings and collections to provide further assurance that they meet our specification. Our aim is to confirm that the most significant content owned by IU, as selected by curators from the media-holding units themselves, was digitized accurately.

4.1.4. Accepting Risk

We may choose to accept a risk that we consider tolerable, working with it in the interest of achieving a greater gain. For example, the IU Music Library holds some 38,000 open reel tape recordings of student and faculty recitals and concerts dating from the 1950s. While curatorial staff tell us that there are recordings of a number of prominent classical and jazz musicians interspersed within this collection, the majority of items are judged to be of moderate value. That is, they are valuable enough to justify digitization and long-term preservation but are not considered highly valuable. In addition, some of the most valuable tapes were digitized as part of an earlier project. Digitizing this collection using parallel transfer workflows may entail a greater risk than using 1:1 workflows, but IU is willing to accept this risk rather than incurring the much higher cost of using 1:1 workflows. Our calculations indicate that it would take 27.86 years to digitize this collection using a single 1:1 workflow versus 7.43 years for one parallel transfer workflow that digitizes four recordings simultaneously.

The boundaries between these risk response procedures can be a little blurry. For example, transferring risk can also be thought of as a form of avoiding risk for the party that gave the risk to another entity. Also, reducing risk can imply accepting what is left of the risk after it is reduced (Hubbard, 2009).

4.1.5. Identifying and Assessing Risk

The questions listed below may help organizations identify and assess risk when building a QC workflow. This is by no means a standard or comprehensive look at identifying/assessing risk. Rather, it presents illustrative questions that MDPI found helpful in developing its QC workflow.

1. How much automated QC can be put into place?

Automated QC can easily provide checks on 100% of files delivered. It is also used to perform checks on points that software can handle more quickly and with greater accuracy than human beings. Using it on a daily basis is not costly. Therefore, as much automated QC should be developed as resources and expertise allow.

2. How much human-intensive QC is needed?

The answer might depend on the kind of material digitized. For example, a collection of open reel tapes recorded for radio broadcast may require less human-intensive QC than a collection recorded in the field. Radio collections are typically recorded by professionals using pro machines and tape stock in a professional setting. They are recorded in a standard, consistent way in terms of technical characteristics. Conversely, field recordings may be recorded anywhere by academicians who have little or no recording experience. Field collections are often heterogeneous and may contain anomalies such as changes in speed or reversed audio that may or may not be intentional. Field collections may require more human-intensive QC to validate that these problems were either not present or were found and resolved during digitization.

3. Where are the judgment calls in the QC workflow?

Workflow steps that require digitization operators to make choices, judgment calls, or interpretive decisions need human-intensive QC to evaluate their accuracy. For example, chroma adjustments for digitization of a videotape rely, in the absence of reference color

bars, upon the operator's interpretation of proper saturation and hue levels that are the most natural looking and accurate.

4. What can go wrong in a workflow? What do we think cannot go wrong?

It is useful to list all of the steps in a workflow in which something can go wrong. This list may be expanded and refined based on experience as the project proceeds. It is also helpful to list workflow steps in which we believe there is little or no chance of error. If such steps exist, they may require fewer QC resources.

5. Are QC resources limited? How can they be allocated most effectively?

It may help to determine the relative value of content to support effective allocation of resources.

6. What risks are acceptable? Which ones are unacceptable?

Answers to these questions are specific to an individual institution's goals, available resources (including funding and expertise), and designated uses of the digitized content.

5. Conclusion

It is critical to acknowledge and confront the risks inherent in digitization work for the sake of future staff who must manage preserved content and for future researchers who must rely on the content for their inquiry. Although it is not possible to remove or reduce all risk associated with media digitization, it is feasible to manage risk through the QC system to give a high level of confidence that the products of digitization meet a designated specification. Using procedures for transferring, avoiding, reducing, and accepting risk enables staff to find problems, prevent problems, reduce the likelihood that problems will occur, and understand areas in which a small number of problems are acceptable. Understanding the types of QC available, and how to implement them, helps stretch and focus scarce resources. All of this engenders trust in the output of the digitization process.

Thanks to Patrick Feaster for his assistance with this article.

Reference List

ASQ: The Global Voice for Quality (2018). *What are Quality Assurance and Quality Control* [online] Available at <http://asq.org/learn-about-quality/quality-assurance-quality-control/overview/overview.html> Accessed 5 Sept. 2018.

Hubbard, D. (2009). *The Failure of Risk Management: Why It's Broken and How to Fix It*. Hoboken, New Jersey, p. 4.