

# **VMAF Compression Ratings that Disregard Camera Impairments (VCRDCI) Dataset**

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***Technical Memorandum***

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**U.S. DEPARTMENT OF COMMERCE**

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## **DISCLAIMER**

Certain products, technologies, and corporations are mentioned in this report to describe the experiment design. The mention of such entities should not be construed as any endorsement, approval, recommendation, prediction of success, or that they are in any way superior to or more noteworthy than similar entities that were not mentioned.

## PREFACE

This memorandum is part of a series of NTIA Technical Memorandums. Each publication describes a subjective experiment that is named in series and distributed freely on the Consumer Digital Video Library (CDVL) website ([www.cdvl.org](http://www.cdvl.org)) for research and development purposes. These experiments provide training data for no-reference (NR) metrics that focus on consumer camera applications. The reader is expected to have some knowledge of subjective experiments. A tutorial on this subject can be found in “[Video Quality Assessment: Subjective testing of entertainment scenes](#),” by Margaret H. Pinson, Lucjan Janowski, and Zdzislaw Papir, published in *IEEE Signal Processing Magazine*, January 2015.

The experiment described by this memorandum, referred to as the VCRDCI experiment, was conducted using the Netflix Video Multi-Method Assessment Fusion (VMAF) full reference video quality assessment tool. VMAF produces simulated mean opinion score (MOS) data for a video. There was no subjective testing used in this experiment.

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## GLOSSARY OF TERMS

ACR	absolute category rating
AOMedia	Alliance for Open Media
AV1	AOMedia Video 1
AVC	Advanced Video Codec, also known as H.264
CDVL	Consumer Digital Video Library
CRF	constant rate factor
FR	full reference
HD	high definition
HEVC	High Efficiency Video Codec, also known as H.265
ITS	Institute for Telecommunication Sciences
ITU	International Telecommunication Union
JSON	JavaScript Object Notation
MOS	mean opinion score
MPEG	Moving Picture Experts Group
NR	no reference
NTIA	National Telecommunications and Information Administration
SVT-AV1	Scalable Video Technology for AV1
VCEG	Video Coding Experts Group
VCRDCI	VMAF Compression Ratings that Disregard Camera Impairments
video codec	video <i>encoder/decoder</i> software that compresses and decompresses a digital video signal
VMAF	Netflix Video Multi-Method Assessment Fusion
VQEG	Video Quality Experts Group

# VMAF COMPRESSION RATINGS THAT DISREGARD CAMERA IMPAIRMENTS (VCRDCI) DATASET

Robert Grosso and Margaret H Pinson<sup>1</sup>

This memorandum provides technical details of the VCRDCI dataset. This dataset was designed similarly to a video quality subjective experiment, but the VMAF metric was used to create simulated subjective data. The VCRDCI dataset contains 130 scenes that have been rescaled to eight resolutions and compressed into 10 variable bitrates with three codecs. The goals are (1) to provide a dataset for developing no-reference (NR) metrics that track the image quality of commonly used codecs, (2) to understand characteristics of videos that have complex interactions with video codecs, (3) to understand the relationship between public safety use cases and acceptable levels of compression, and (4) to develop a metric that responds strongly to the effects of video compression.

Keywords: camera capture, no-reference metric, public safety, video quality

## 1. INTRODUCTION

The VCRDCI dataset was designed to provide insights into no-reference (NR) metrics that disregard camera impairments and focus instead on the encoding artifacts that result from compression. The videos in the VCRDCI dataset represent many topics digitally recorded with a variety of consumer-grade and broadcast-grade cameras. The VCRDCI dataset implements an experiment design with 130 scenes, each scaled and compressed to a matrix of resolutions and quality factors. The videos are organized by scene, each scene folder containing the full matrix of scaled and encoded videos using each encoder.

The goal of the VCRDCI dataset is to characterize the impairments for each codec's compression scheme and provide training data for a metric that can accurately detect encoding impairments. Each codec used has a mode that will encode the video with a "Constant Quality" attribute but variable bitrate. The quality of the video is measured and interpreted by the encoder, and the user chooses a quality parameter from 0 to 55. A constant rate factor (CRF) of 0 is a lossless compression, while 55 is the worst possible encoder setting. The VCRDCI dataset contains the source video, 240 down-converted videos for each scene (8 resolutions  $\times$  10 constant rate factors  $\times$  3 codecs), and 240 re-scaled videos back to  $1920 \times 1080$ , creating 481 total video files for each scene.

The VCRDCI dataset was designed to:

- Train NR metrics that track the video quality

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- Portray spatial characteristics of complex interactions with video codecs, such as water and leaves
- Provide quality ratings that are only affected by encoding impairments
- Enable machine learning techniques
- Show camera capture impairments that are not reflected in the quality ratings

This memorandum provides a technical description of the dataset design and implementation and provides a brief analysis of the ratings. Analyses of the dataset will appear in separate publications with only a summary of the dataset design. The VCRDCI dataset is available on the Consumer Digital Video Library (CDVL) website ([www.cdvl.org](http://www.cdvl.org)). See the CDVL website for licensing terms. Appendix A provides attribution information for each specific video.

The VCRDCI dataset is an exploratory study due to the use of the Netflix Video Multi-Method Assessment Fusion (VMAF) metric version 2.3.0 to create simulated mean opinion scores (MOS).

## 1.1 Background

This memorandum is part of a series of NTIA Technical Memorandums. Each publication describes a subjective experiment that is named in series and distributed freely on [www.cdvl.org](http://www.cdvl.org) for research and development purposes. These experiments provide training data for NR metrics that focus on consumer-camera applications. NR metrics trained on these datasets will be appropriate for assessing modern cameras and high-performing networks (wired and wireless). Suitable applications include professional and amateur photography, broadcast television, adaptive video streaming, video surveillance, videoconferencing, and media embedded in websites. Metrics trained on these datasets will be unsuitable for contribution-quality video applications, where bit rates are higher, impairments differ, and artistic intent must be considered.

The goal of an NR metric is to predict the quality of an image or video using only the image or video itself. That is, NR metrics examine pixels, not bit-streams or coding parameters, and NR metrics cannot refer to a higher-quality version of the image or video. At Video Quality Experts Group (VQEG, [www.vqeg.org](http://www.vqeg.org)) meetings, industry has expressed an urgent need for NR video-quality metrics. NR metric development has proven to be a very challenging endeavor. VQEG brings international experts together from industry, academia, government, the International Telecommunication Union (ITU), and other standards-developing organizations (SDO). VQEG conveys industry needs to academic researchers and leverages resources from multiple organizations to facilitate the development of improved methods for video quality assessment.

The VCRDCI dataset builds upon a prior image-quality subjective experiment, named ITS4S2 [1]. The ITS4S2 experiment produced the ITS4S2 dataset, which was designed to provide insights into NR metrics that evaluate camera capture. The images in the ITS4S2 dataset represent many topics digitally photographed with a variety of consumer-grade cameras. The ITS4S2 dataset implements an experiment design with unrepeated scenes. Seventy-five percent

of the images depict unique scenes, and 25% show the same scene photographed in two to three different ways. The images are organized by topic (e.g., disaster response, fireworks, snow sculpture) and impairment (e.g., fisheye lens, Bokeh effect). The goal is to characterize the entire camera capture pipeline: sensor, image processing encoder, decoder, and display. The ITS4S2 dataset contains 1,473 digital images from amateur photographers, though some photographers self-report as professional. The images were obtained from Flickr®.

The ITS4S2 dataset was designed to:

- Train NR metrics that track the image quality of consumer-grade cameras
- Portray spatial characteristics of moving objects that have complex interactions with video codecs, such as water and confetti
- Explore any differences in rating behaviors depending on whether the images are used for entertainment purposes or by public safety practitioners for job-related tasks

An interesting outcome of ITS4S2 is there were differences in MOS between public safety practitioners for job-related tasks and entertainment purposes. This hinted at the existence of application-specific MOSs, where certain aspects of impairments might be acceptable for one application but unacceptable for another. Broadcasters, videoconferencing services, content streaming services and public safety practitioners are commonly interested in encoding impairments. All NTIA/ITS related stakeholders mentioned have an interest in providing greater video quality per unit bitrate. Broadcasters are working with images and videos that are engineered for content, so any camera impairment present in the source video could be intentional (e.g., a found footage movie with shaky camerawork). Encoding impairments would be introduced in the data-serving pipeline to account for channel bandwidth. Public safety practitioners are interested in encoding impairments introduced in surveillance video streams, body camera streams, and the total file size of high-quality video when stored according to [2]. Both Broadcasters and public safety practitioners need a metric that is very sensitive to encoding impairments and nothing else. The VCRDCI dataset aims to fill this need by providing training and testing data using scaling and encoding parameters in use by industry today.

The core idea of the VCRDCI dataset is to use a full-reference (FR) metric to create simulated MOS data. This strategy has been proposed during VQEG meetings. Prior work implementing this idea include [3], which provides few details about the videos; [4], which uses a small number of videos and an extremely large number of impairments; and [5]–[6], which describe a transcoding solution based on Scalable Video Technology for AV1 (SVT-AV1). Where these datasets contain high-quality videos (before compression), the VCRDCI dataset intentionally includes low-quality videos with camera impairments. Because the FR metric will not detect these camera impairments, any NR metric trained on the VCRDCI dataset should likewise not respond to camera impairments. This space has a lot of potential. Given an FR metric that reliably responds to a specific impairment or attribute, we can easily create a dataset suitable for training an NR metric that detects that impairment or attribute. The main limitation of this approach is that FR metrics cannot detect impairments that are in the original media recording (i.e., impairments associated with the camera capture, the camera operator’s behaviors, editing,

and animation quality). This strategy is only viable for impairments associated with video processing, encoding, transcoding, transmission, decoding, and display.

The VCRDCI dataset is designed to use simulated MOS data that is generated from only encoding impairments, while disregarding content, artistic style, and camera impairments. The Netflix VMAF is a full-reference metric, a description can be found in [7]. VMAF calculates quality based on the difference between an original and distorted video, compared pixel by pixel. By only adding compression impairments to the distorted video, the VMAF data is directly correlated to encoding impairments through the VMAF process chain. This approach has some advantages:

- Capable of evaluating datasets much larger than would be practical for subjective tests
- Supports many more scaling and encoding levels than would be reasonable for subjective testing
- Permits the elimination of camera capture impairments, leaving them for other studies

The dataset generated about 2 terabytes (TB) of compressed video. This breaks down to 240 videos for each scene and 130 scenes, resulting in 31,200 videos to rate. Accurate MOS data would require 24 ratings for each video according to [8]. So, this dataset would require 748,800 ratings from screened subjects, which is infeasible for the data needed to train a machine learning algorithm. The number of videos and amount of scene repetition would create a test that is very tedious and would lead to subject fatigue, which decreases the accuracy of ratings. Introduction of the human element also accounts for artistic style, camera impairments, and content choice. A user may be more focused on other impairments or content that detracts from attention given to the quality of the video relative to the compression. Using a simulated MOS approach eliminates the human factor and allows processing of large amounts of data, regardless of scene re-use and content.

There are also some disadvantages to using simulated MOS data, as listed below:

- Any flaws within the VMAF model will be reflected in any algorithm trained on this dataset
- Nonlinear combination of impairments on MOS will not be captured (e.g., the relationship between two encoding settings changes as bitrate drops)

Limitations in the VMAF model apply. For instance, VMAF does not simulate comparative differences in frame rates. Any inaccuracy or impairment in the way VMAF compares videos will carry through to the MOS. This dataset is designed to disregard camera impairments, but such an impairment combined with encoding could produce a non-linear effect where the real MOS is lower than the simulated MOS. Such non-linear effects will not be captured using simulated MOS data.

## 1.2 Dataset Overview

The VCRDCI experiment design adopts the strategy of using VMAF-generated scores as MOS data for video quality assessments. In this regard, the VCRDCI dataset was developed to provide insight into encoding impairments and recognizing those effects on a varied landscape of videos, ranging from broadcast-quality to user-generated videos.

The VCRDCI dataset diverges from the conventional experiment design in four ways:

- There is a high number of scene repetitions, as this dataset was never designed to be viewed by humans.
- The scenes were chosen with disregard to camera impairments.
- The MOS scores are derived from the Netflix VMAF suite instead of generated from subjective testing.
- Instead of compressing the videos to a target bit rate, each resolution is compressed into different “quality factors” which keeps the quality constant but varies the compression. Quality, and the determination of quality, is left to the encoder algorithm.

## 1.3 Dataset Organization

The VCRDCI organizes the data into a file structure with a subfolder for each scene. The scene’s subfolder contains the original video, the full distorted matrix (8 resolutions  $\times$  10 CRF encodings  $\times$  3 codecs) and associated re-scaled files, along with the corresponding JavaScript Object Notation (JSON, .json) file that contains the VMAF rating. Figure 1 shows the container folders for scenes 1 through 11, each with a container folder named after the original video file. Each subfolder contains:

- The original file
- The control encoding
- Various compressed encodings
- The JSON rating files for the control and compressed encodings

Figure 2 shows the first ten files of one of these subfolders.

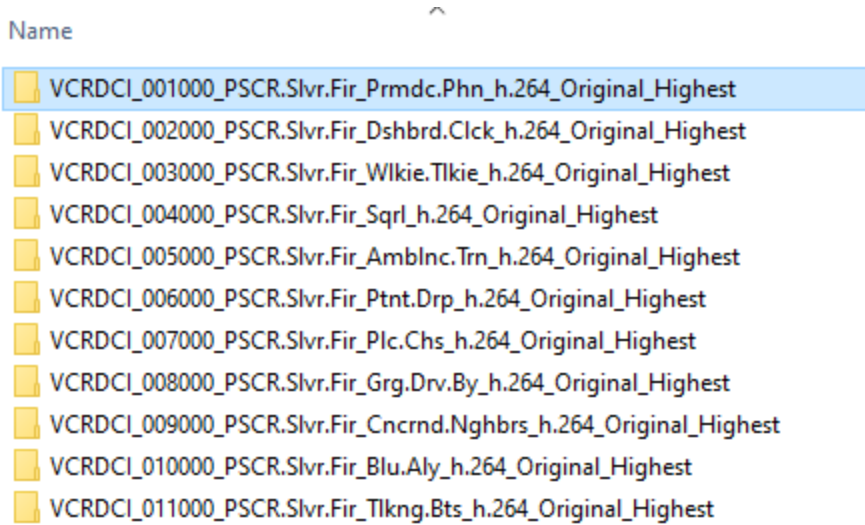


Figure 1. VCRDCI root folder structure.

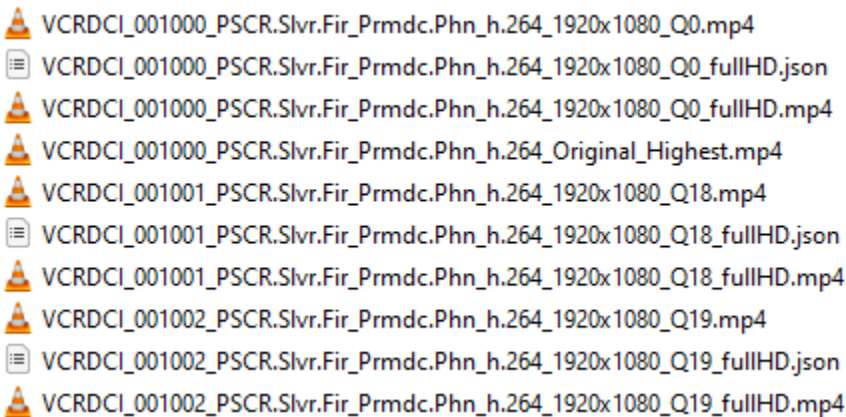


Figure 2. VCRDCI\_001000 folder structure.

The dataset contains 130 folders. Each folder contains every file associated with this scene. The folder contains the original video, encoded in h.264 at 23.98 fps with a high enough bit rate to avoid introducing encoding artifacts in the source video. The source video is the only .mp4 in the folder named “\_Original\_Highest” as it was encoded with original resolution and with a bit rate greater than the peak bit rate in the original video. The first encoded video has the same identifying number as the original video, as this is encoded with lossless compression in the original format resolution, and acts as a control to the original file. For each compressed scene, there are two video files associated with the same number, but one contains a “fullHD” tag at the end. The file without the “fullHD” tag is the distorted and scaled video, while the file with the “fullHD” tag is re-scaled to  $1920 \times 1080$  to allow VMAF to compare pixel to pixel. Note that the re-scaling to  $1920 \times 1080$  is an integral component of adaptive video streaming, and thus required by VMAF.

Uncompressed .yuv files for each video were created to use with VMAF but have not been included due to size constraints. It is up to the researcher to generate these files on the fly while



using VMAF to re-rate this dataset if the situation arises. YUV files contain pixel values without any format or header information.

VMAF ratings are exported and saved in a .json file named after the re-scaled video. The .json file contains frame-by-frame ratings along with a mean rating of all frames on a 0–99 scale.

The dataset has a naming convention that gives each element in the scene matrix a unique name. Figure 3 describes the naming convention for the first scene in the dataset (number 001000). The convention is shown for the original file, the control encoding, and the first compressed video (number 001001).

VCRDCI Naming Convention

File name example VCRDCI\_001000\_PSCR.Slvr.Fir\_Engn.36\_h.264\_Original\_Highest

Before Abbreviation	VMAF Compression Ratings that Disregard Camera Impairments		2017 PSCR Silver Fir Rain Snow	Engine 36			
After Abbreviation	VCRDCI	001000	PSCR.Slvr.Fir	Engn.36	h.264	Original	Highest
Field Description	Database	Identification #	Media Source	Scene	Encoding scheme	Resolution	Bit Rate

File name example VCRDCI\_001000\_PSCR.Slvr.Fir\_Engn.36\_h.264\_1920x1080\_Q0

Before Abbreviation	VMAF Compression Ratings that Disregard Camera Impairments		2017 PSCR Silver Fir Rain Snow	Engine 36			
After Abbreviation	VCRDCI	001000	PSCR.Slvr.Fir	Engn.36	h.264	1920x1080	Q0
Field Description	Database	Identification #	Media Source	Scene	Encoding scheme	Resolution	Bit Rate

File name example VCRDCI\_001001\_PSCR.Slvr.Fir\_Engn.36\_h.264\_1920x1080\_Q18

Before Abbreviation	VMAF Compression Ratings that Disregard Camera Impairments		2017 PSCR Silver Fir Rain Snow	Engine 36			
After Abbreviation	VCRDCI	001001	PSCR.Slvr.Fir	Engn.36	h.264	1920x1080	Q18
Field Description	Database	Identification #	Media Source	Scene	Encoding scheme	Resolution	Bit Rate

Figure 3. VCRDCI naming convention.

General Naming Notes:

- VCRDCI uses Department of Defense (DoD) style abbreviations [9] — for words that are greater than 3 characters, omit vowels and double letters except where ambiguous
- Separate terms with underscore, separate words within the same term with period, avoid spaces for ease of programmatic uptake
- Resolution is written as “WidthxHeight” for Width × Height (e.g., 1920 × 1080 becomes 1920x1080)
- CRF is a quality factor ranging from 0–55 described later in this paper, with a prefix of “\_Q”

Each scene in the dataset is registered in a spreadsheet to keep track of the full name and source of the video. Due to the naming and numbering convention, it was necessary to provide a complete description of the video and to ensure no number is reused and names are shown without abbreviation. The VCRDCI dataset register is included with the distribution of the dataset.

## 2. EXPERIMENT DESIGN

### 2.1 Video Selection and Categorization

All videos are categorized into the scene selection sets identified in Table 1. These scenes were chosen to highlight one or more aspects of compression difficulty for a video codec.

The VCRDCI dataset includes scenes that contain public safety content, rain, snow content, entertainment content, natural scenes, and abstract scenes. Public safety is the main concern of this dataset, and most scenes were selected with first responder content in mind. The rest of the dataset’s scenes were selected for non-public safety use cases (e.g., entertainment). Scenes were selected without consideration of camera impairments but were selected based on perceived difficulty for efficient compression. Some content of the dataset was selected to be especially confounding to machine-learning algorithms, as this is the dataset’s target audience. The data is split into training and verification data.

Appendix A contains the attribution information and licensing terms for each video. Take care when selecting videos from this dataset for use in publications, presentations, or demonstrations. Some of the videos may have constraints around attribution, commercial applications, or derivations. ITS has full distribution rights for the videos that were selected for the VCRDCI dataset, to minimize these use constraints.

Table 1. Scene Selection Descriptions and Motivations

Category	Description	Motivation
<b>Abstract</b>	Abstract art, unusual shapes and lines	Demonstrate unusual shapes and lines that may be problematic for NR metrics and object recognition
<b>Natural scenes</b>	Waves, other natural scenes with significant spatial information	Show objects that are difficult for video encoders, because they move erratically and change shape unexpectedly; these videos have a significant amount of spatial information
<b>Public Safety</b>	Scenes related to a public safety use case	Public safety scenes commonly encountered by first responders
<b>Rain+Snow</b>	Scenes which have rain or snow features as the dominant content	Rain and snow present a significant amount of spatial and temporal information. Along with the difficulty of encoding, it creates a challenging environment for first responders while also creating an obstacle for computer vision algorithms.
<b>Entertainment</b>	Scenes that broadcasters and video streamers might host to users	Some content has fast-moving objects, and is representative of entertainment-quality content

### 2.2 Other Video Selection Considerations

As the name of the VCRDCI dataset suggests, the videos were not controlled for camera or other impairments. There are some scenes where blur is natural, and some scenes where the lighting is not ideal. Some scenes are too dark, some scenes have the camera looking directly into the light. The research team wanted to emulate many different scenes and settings that a first responder

would encounter. One or two scenes may have excessive black borders; these can be used to test the robustness of a metric. Source video that already had encoding impairments was excluded.

The team evaluated the response of VMAF when the original video has camera capture impairments. VMAF does not appear to have any undesirable behaviors when the original video has camera capture impairments. Our ad hoc evaluation indicates that VMAF only responds to added compression artifacts (i.e., impairments associated with a processing chain that includes scaling, encoding, and decoding). This observed behavior matches statements made by broadcasters of the broadcast use case (for which VMAF was developed), where the quality impact of camera capture impairments is ignored as being the “artistic intent” of the original video. Thus, the VMAF ratings are suitable for training a metric that responds only to compression artifacts.

VMAF is designed for source footage that is natively  $1920 \times 1080$ . Some videos have excessive black borders to make the effective video clip smaller, but most selected source videos cover the full pixel space of  $1920 \times 1080$ . VMAF can also be used with 4K content, but we did not use this option when creating the VCRDCI dataset.

Interlaced videos were excluded, as progressive formats dominate most modern use cases. A metric based on the VCRDCI dataset might respond poorly to interlaced videos that are played within a progressive video stream without being properly converted. Most video services use progressive formats. Currently, interlaced videos are primarily used for the broadcast use case (e.g., digital television transmission over satellite networks).

All video frame rates have been downsampled to 23.97 fps. Since the overall VMAF rating of a video is a simple mean of all VMAF frame values and each frame is compared against the corresponding frame of the original, frame rate has been deemed irrelevant and is thus standardized across videos. Videos are controlled to be 4–8 seconds long with an absolute maximum length of 30 seconds.

## 2.3 Encoder Selection

H.264/AVC (Advanced Video Codec) has been the standard of video codecs for the last decade due to the substantially low bitrates compared to previous generations of encoders [10]. H.264 was standardized by the ITU-T Video Coding Experts Group (VCEG) of Study Group 16 together with the ISO/IEC JTC1 Moving Picture Experts Group (MPEG). Approximately 91% of video industry developers use H.264 [11]. Due to its widespread use, H.264 is included in the VCRDCI dataset.

Later, H.265/HEVC (High Efficiency Video Codec) was created by the ITU-T VCEG of Study Group 16 together with the ISO/IEC JTC1 MPEG. H.265/HEVC is designed to be the successor to H.264/AVC. H.265/HEVC is the second most used video codec after H.264. Due to its proliferation, H.265 is also included in the VCRDCI dataset.

AV1 is gaining popularity in the video codec space and was created by the Alliance for Open Media (AOMedia) as a royalty-free video codec and successor to VP9<sup>2</sup>. Due to promising results posted by Facebook and others [12], AV1 is included in the VCRDCI dataset.

## 2.4 Resolution Selection

Content providers use a bit stream ladder to deliver video streams to users of various devices. The video hosting pipeline will measure the bandwidth of the channel in real time and provide a video stream appropriately sized for data throughput. The data pipeline will scale the resolution of the video to compensate for reduced bandwidth with set levels of resolutions to produce steps in descending bandwidth or “rungs” of the bit stream ladder. Netflix,<sup>®</sup> Apple,<sup>®</sup> Microsoft,<sup>®</sup> Google,<sup>®</sup> Amazon,<sup>®</sup> and others have all used this technique at some time [13]–[18]. The research team examined the resolutions used by industry and found the resolutions in Table 2 and Table 3 to be the most hosted in the providers’ bit rate ladder schema.

Table 2. High Resolutions and Associated Names

Name	4K	2K or 1440	Full HD	High Definition (HD)	Quarter HD (qHD)
Resolution	3840 × 2160	2560 × 1440	1920 × 1080	1280 × 720	960 × 540

Table 3. Standard Resolutions and Associated Names

Name	Standard Definition TV (SDTV)	N/A	Video Graphics Array (VGA)	N/A	Common Intermediate Format	Quarter VGA (qVGA)
Resolution	720 × 480	768 × 432	640 × 480	512 × 384	384 × 288	320 × 240

After comparing the resolutions listed above, the research team paired down this list to resolutions that were the most used across providers. High resolutions such as, 3840 × 2160 (4K) and 2560 × 1440 (2K or 1440) were usually hosted as premium service offerings [19] by the common video steaming providers. But due to the limitations of the source content of VCRDCI, these two resolutions were excluded. Most of the ITS source videos would need to be upconverted to these resolutions. Encoding impairments in high-quality streams are also of interest, but for now the VCRDCI set excludes 4K and 1440 content. Of the remaining resolutions, 720 × 480 has been omitted, as the total pixels represented are similar to 768 × 432, but 768 × 432 has a perfect 16:9 aspect ratio.

<sup>2</sup> VP9 is an open and royalty-free video codec developed by Google.

Aspect ratio is another consideration the research team had to understand, as most source content is in  $1920 \times 1080$  with a native aspect ratio of 16:9. Some of the chosen resolutions do not share this aspect ratio, so an adjustment of resolution, cropping, or black borders must be implemented to rectify the aspect ratio difference. Private communication with industry experts provided the research team with an industry preference to include black borders instead of cropping artistic content when dealing with aspect ratio changes.

The VCRDCI dataset only includes 16:9 aspect ratios. The borders do not add information to the video (i.e., will not contain compression impairments) and detract from some NR metrics' ability to interpret the video. Therefore, the research team opted to adjust the video resolutions to those with 16:9 aspect ratios. The width of the resolution is kept constant, but the height is adjusted to eliminate the need for top and bottom black borders. Following are the final resolution selections:

- $1920 \times 1080$
- $1280 \times 720$
- $960 \times 540$
- $768 \times 432$
- $640 \times 360$
- $512 \times 288$
- $384 \times 216$
- $320 \times 180$

## 2.5 Constant Rate Factor Selection

Each encoding algorithm has modes for constant bit rate and variable bit rate encoding. Variable bit rate encoding allows the encoder to save bandwidth over frames that have little change in information, or by recognizing areas that can be compressed heavily with no change in perceived quality. The encoder developers call this mode “constant quality.” The encoder is given user input and the encoder is left to determine the level of quality that corresponds to this input, keeping perceived quality constant while bitrate changes. The user inputs a CRF, which is an integer that ranges from 0 to 55. A CRF of 0 indicates a lossless compression, while a CRF of 55 is the most possible compression. A CRF of 18 is considered equal quality to the input video [20].

Netflix extends the bit rate ladder to a second dimension, with the CRF occupying the 2<sup>nd</sup> dimension. Netflix created a CRF and resolution encoding matrix with 84 possible encodings that can have CRF values of 18, 19, 20, 22, 25, 27, 30, 35, 40, 45, 50, and 55 [21].

When viewing a video encoded in H.264 with each of these factors, the research team decided that CRF values of 45, 50, and 55 would be omitted due to the very poor quality of these factors. The research team viewed [22] for another industry gauge of quality-defined variable bit rate schemas when deciding on the final CRF values.

The final matrix of all encodings we refer to as the “scene matrix” as each source video is encoded into each element in the matrix. A single scene will produce all possible videos (i.e., CRF  $\times$  resolution) for Table 4 for each codec (H.264, H.265, and AV1).

Table 4. Rating Matrix

	1920×1080	1280×720	960×540	768×432	640×360	512×288	384×216	320×180
0								
18								
19								
20								
22								
25								
27								
30								
35								
40								

## 2.6 Methods

The team used Adobe Premiere Pro® to edit the source videos. The edited videos were distorted using FFmpeg<sup>3</sup> and then up converted to 1920  $\times$  1080 also using FFmpeg. The up-conversion is performed with the same encoder as the distortion process. The scene was checked for errors and transferred to an external drive to be rated on a separate computer.

VMAF worked well on Ubuntu, so Ubuntu 20.04 was used to run the VMAF algorithm. Once present on the Ubuntu computer, the researchers used a python script to convert to the .yuv file format required by VMAF, rate the video, and delete the .yuv file to avoid exhausting disk space. VMAF exports the rating information in a .json file named after the distorted video, with a rating for each frame and a mean rating taken across all frames in the clip.

During the rating process, the Microsoft Windows® computer generates uncompressed .avi files for programmatic uptake into MATLAB.® After importing the uncompressed avi files, MATLAB will export a dataset spreadsheet with a row for each file in the dataset. A script is included to iterate through all .json rating files and input the MOS into the MATLAB dataset spreadsheet. The ratings are linearly scaled from the raw 0–99 scale to the absolute category rating (ACR) 1–5 scale and used as MOS data (i.e., VMAF / 25 + 1). Using the script files and

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<sup>3</sup> FFmpeg is a free and open-source software project consisting of a suite of libraries and programs for handling video, audio, and other multimedia files and streams. [www.ffmpeg.org](http://www.ffmpeg.org)

framework developed to create this dataset, the reader can generate many more terabytes of video data for further research.

## 2.7 Video Data Generation Process

Figure 4 provides a diagram of the process chain used to generate the VCRDCI dataset.

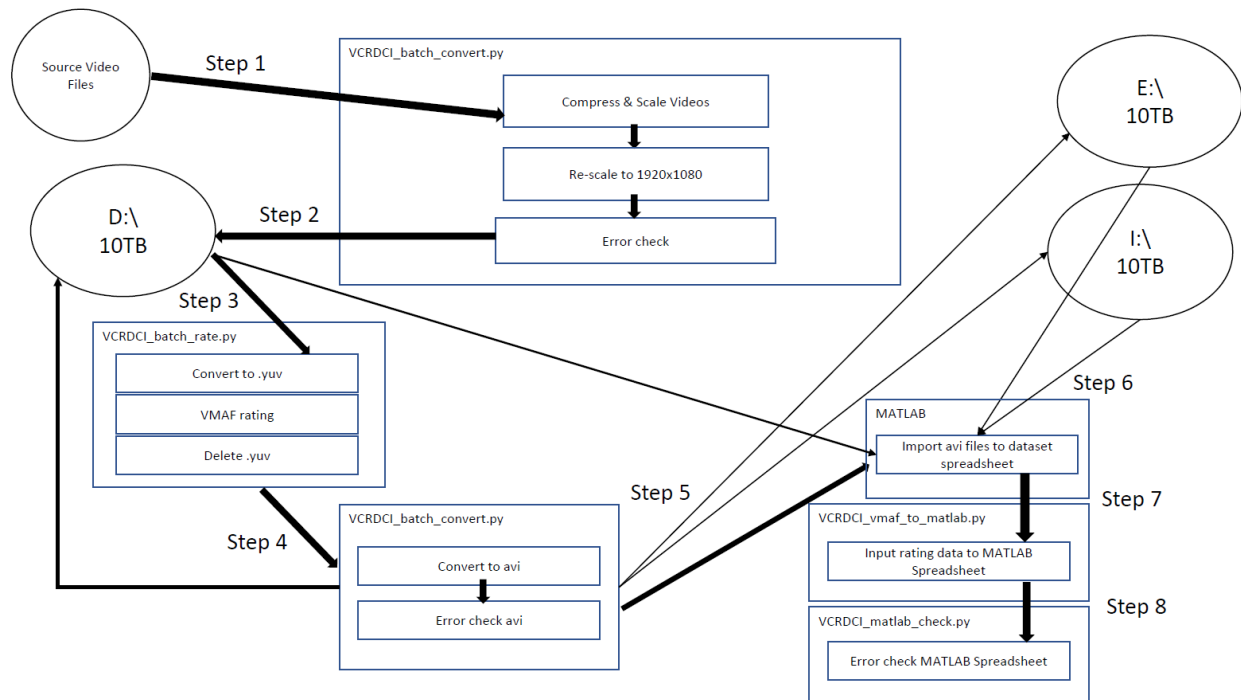


Figure 4. VCRDCI video data process flow using three 10-TB hard drives.

The following steps describe the process for generating the VCRDCI data:

Step 1: Source videos are compressed and scaled, then re-scaled to  $1920 \times 1080p$

Step 2: The distorted and rescaled videos are placed on a 10-TB drive

Step 3: The 10-TB drive is moved to an Ubuntu computer where the script `VCRDCI_batch_rate.py` is run to obtain the ratings of all videos

Step 4: The 10-TB drives are moved to a Windows computer and span across drives `D:\`, `E:\` and `I:\`. The  $1920 \times 1080$  re-scaled videos are used to generate the uncompressed dataset

Step 5: The uncompressed avi dataset is checked for errors (e.g., each file exists and can be read)

Step 6: The uncompressed dataset is imported into the MATLAB dataset format used by the `NRMetricFramework` repository [23]

Step 7: The MATLAB dataset is exported to a spreadsheet, `VCRDCI_vmaf_to_matlab.py` enters the JSON data into the MATLAB spreadsheet as MOS data

Step 8: The MATLAB dataset spreadsheet is checked for errors (e.g., the automatically-calculated overscan region looks reasonable)

By providing the tools and framework used to generate the VCRDCI dataset, the research team aims to enable the reader to continue this experiment and further the amount of training data available to future algorithms.



### 3. DATASET DISTRIBUTION

The VCRDCI dataset is available on [www.cdvl.org](http://www.cdvl.org) for research and development purposes. VCRDCI provides:

- A folder for each scene containing:
  - The original video
  - 4–8 second scaled and compressed videos (240 for each scene)
  - Re-scaled videos to  $1920 \times 1080$
  - Simulated ratings (.json file with a rating for each frame and a mean for all frames)
- Spreadsheet containing a description of all scenes (Microsoft Excel (Excel) file)
- Three spreadsheets describing the uncompressed dataset with raw and scaled MOS data (Excel file)
  - VCRDCI\_1.xlsx
  - VCRDCI\_2.xlsx
  - VCRDCI\_3.xlsx
- Python Script files to accomplish the following tasks: (.py files)
  - Scale and compress source videos
  - Re-scale videos to  $1920 \times 1080$
  - Check for encoding errors
  - Convert videos to .yuv format
  - Rate .yuv videos with VMAF
  - Convert videos to uncompressed .avi format for MATLAB uptake
  - Batch import of rating data to MATLAB dataset
  - Error checking of MATLAB dataset file
  - Import of category data from dataset register

The uncompressed AVI files are not distributed on CDVL due to their extremely large size. The dataset has been generated using an array of 10-TB external hard drives. The uncompressed dataset will occupy 30 TB of hard drive space. It is recommended the reader use a similar sized storage bank when working with the uncompressed dataset.

The VCRDCI dataset is intended specifically to inspire innovative NR metric development around encoder impairments. The VCRDCI dataset emphasizes a large variety of repeated videos which have been scaled and compressed with three different codecs to emphasize the distinct characteristics of the compression artifacts.

Video playback requires a video player that can play all three codecs (H.264, H.265, and AV1) along with lossless formats. Windows Media Player has trouble with H.265, AV1, and lossless encodings. VLC Media Player was used by the team for playback of all videos in the dataset.

## 4. SIMULATED TESTING, POST PROCESSING AND MOS ANALYSIS

### 4.1 Simulated Testing

To compare each video pixel by pixel, VMAF requires the original and distorted videos to be at the same resolution. Videos that have been scaled and compressed must then be re-scaled to the original resolution of  $1920 \times 1080$  to be rated by VMAF. VMAF will only accept uncompressed .yuv formatted files, so each scaled and compressed video needed to be re-scaled to  $1920 \times 1080$  and then converted to uncompressed .yuv to be compared pixel for pixel against the original. VMAF then outputs a rating for each frame and a mean rating of all frames. The mean VMAF score for each video is programmatically scaled to ACR (1–5) and input into the dataset spreadsheet exported by MATLAB. VMAF needed slight modification to save the JSON data as a .json file instead of a terminal output. In the run\_vmaf.py file, the modification was made to dump the json rating data to a .json file named after the distorted input file. The python modifications are detailed in Figure 5, starting immediately below line 151 of run\_vmaf.py.

```
147 | # output
148 | if out_fmt == 'xml':
149 |     print(result.to_xml())
150 | elif out_fmt == 'json':
151 |     print(result.to_json())
152 |     with open(out_file, 'w') as f:
153 |         f.write(result.to_json())
154 | else: # None or 'text'
155 |     print(str(result))
156 |
```

Figure 5. VMAF modification to dump json rating data to file.

### 4.2 Analysis of Simulated MOS Data

Figure 6, Figure 7, and Figure 8 show 3D plots of VMAF scores calculated on the first scene matrix “VCRDCI\_001000\_PSCR.Slvr.Fir\_Prmdc.Phn\_h.264\_Original\_Highest” for each encoder. The plots depict scaled resolution on the x-axis, CRF on the y-axis and VMAF score (0–99) on the z-axis. We can see a pattern of steadily decreasing VMAF scores as the CRF increases or the scaling becomes more acute. When VMAF compares lightly-compressed videos to the original, the score is very close to 100, as expected. This plot shows that VMAF ignores impairments in the original video and responds well to the introduced encoding impairments.

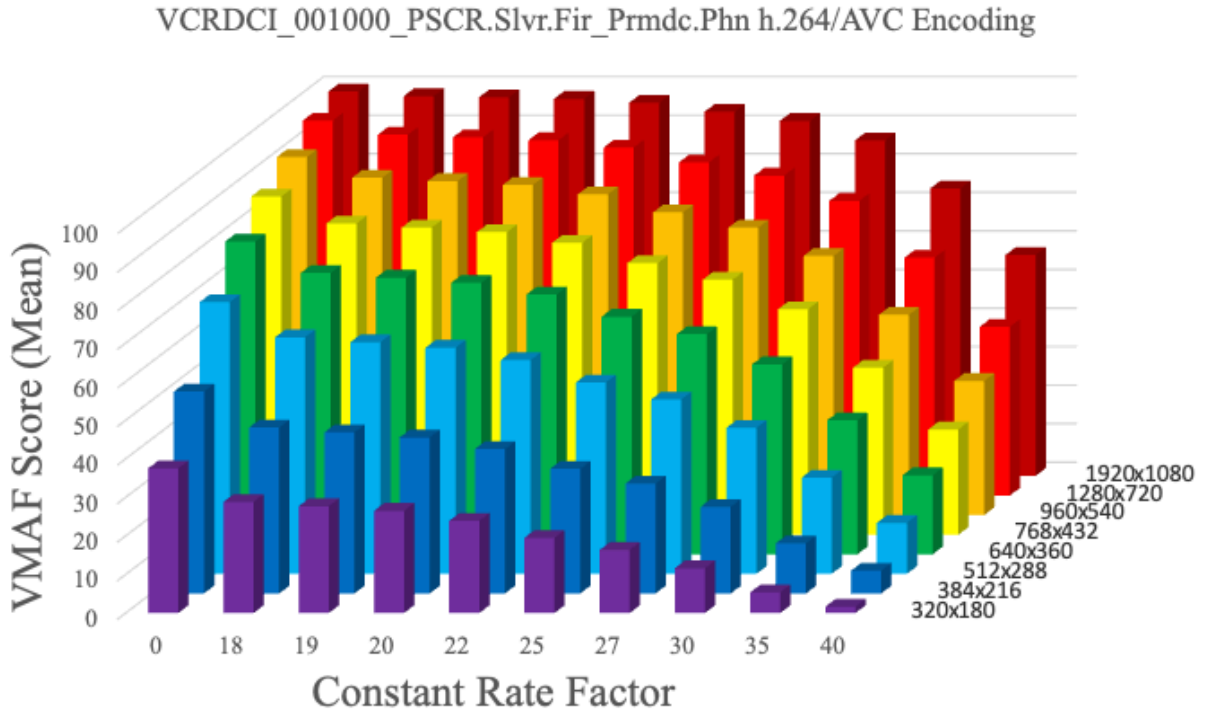


Figure 6. VCRDCI\_001000\_PSCR.Slvr.Fir\_Prmdc.Phn h.264/AVC Encoding.

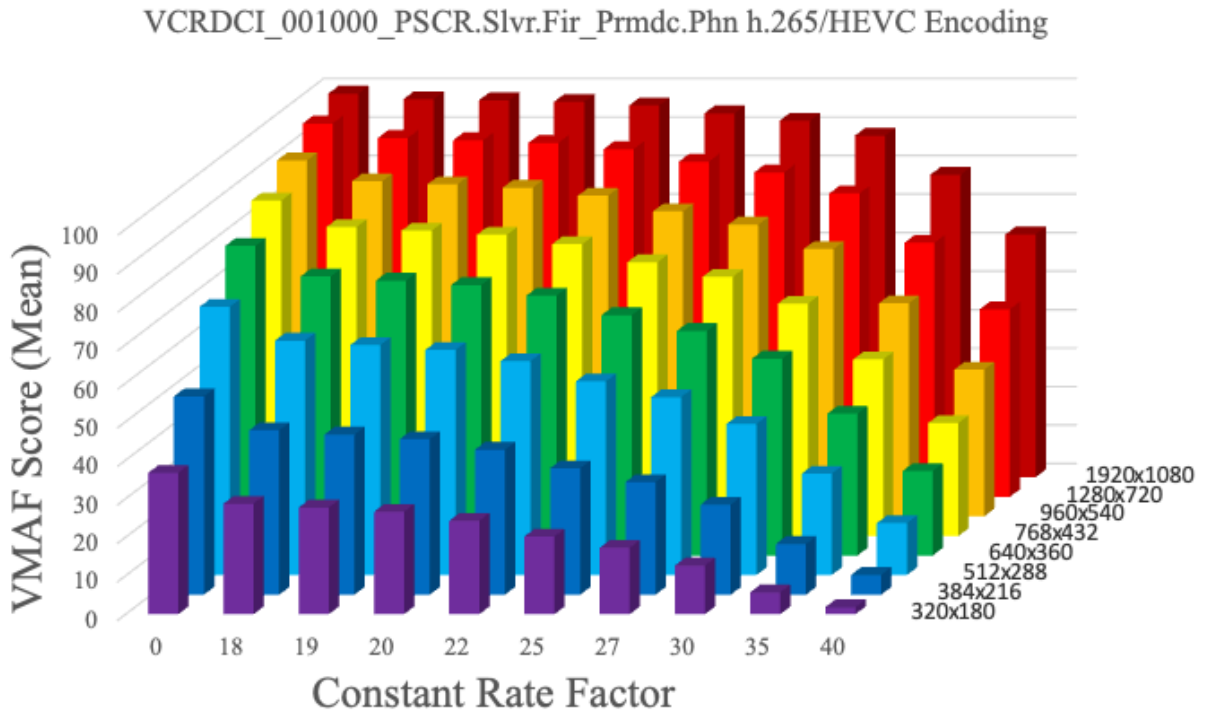


Figure 7. VCRDCI\_001000\_PSCR.Slvr.Fir\_Prmdc.Phn h.265/HEVC Encoding.

### VCRDCI\_001000\_PSCR.Slvr.Fir\_Prmdc.Phn AV1 Encoding

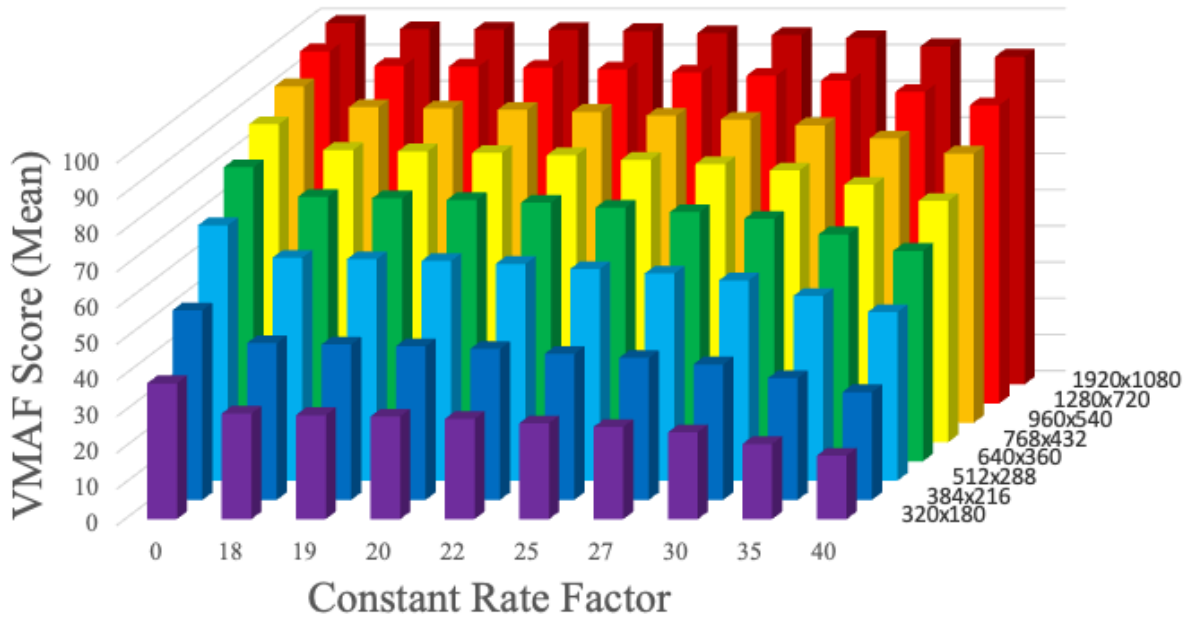


Figure 8. VCRDCI\_001000\_PSCR.Slvr.Fir\_Prmdc.Phn AV1 Encoding.

From the three graphs, we notice that VMAF responds to both CRF and scaling, which is useful for this dataset and shows how calculated perceived-quality maps linearly to the decreased quality in the distorted video. An increased CRF or scaling leads to a greater amount of encoding impairments. We also notice that the AV1 VMAF rating does not drop off as heavily as AVC or HEVC when CRF is increased. This does not necessarily mean that the absolute quality of AV1 videos is superior, just the way VMAF responds to changes in CRF. The effect of resolution on the VMAF score is constant for all three encoders, and the research team did not find any irregularities or non-linearities in VMAF ratings when the effects of CRF and scaling are combined.

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## APPENDIX A: ATTRIBUTION AND USAGE RIGHTS

This appendix contains the attribution and license information for each source video in the VCRDCI dataset. Table A-2 contains the attribution and license terms for the video scenes distributed on the Consumer Digital Video Library (CDVL) website ([www.cdvl.org](http://www.cdvl.org)). Table A-1 defines each column in the attribution tables and spreadsheet.

Caution is advised when displaying or distributing these videos (e.g., conference papers, presentations, technical demonstrations). The use of each video is constrained by the original attribution and licensing terms.

Table A-1. Attribution and License Term Table Description

<b>Column Title</b>	<b>Description</b>
<b>Scene File Name</b>	Name of the video file used to create the distorted scene matrix
<b>Original Video</b>	Source video from which the scene file has been cut
<b>Publication Terms</b>	Publication terms of the original video, which carry through to the Scene File



Table A-2. VCRDCI Attribution and License Terms

Scene File Name	Original File Name	Publication Terms
<b>VCRDCI_001000_PSCR.Slvr.Fir_Prm dc.Phn_h.264_Original_Highest.mp4</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_002000_PSCR.Slvr.Fir_Dshbrd.Clck_h.264_Original_Highest.mp4</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_003000_PSCR.Slvr.Fir_Wiki e.Tlkie_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_004000_PSCR.Slvr.Fir_Sqrl_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_005000_PSCR.Slvr.Fir_Amb Inc.Trn_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_006000_PSCR.Slvr.Fir_Ptnt. Drp_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_007000_PSCR.Slvr.Fir_Plc. Chs_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_008000_PSCR.Slvr.Fir_Grg. Drv.By_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_009000_PSCR.Slvr.Fir_Cncr nd.Nghbrs_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_010000_PSCR.Slvr.Fir_Blu. Aly_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_011000_PSCR.Slvr.Fir_Tlkn g.Bts_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_012000_PSCR.Slvr.Fir_Onlookers_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_013000_PSCR.Slvr.Fir_Police.Line_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_014000_PSCR.Slvr.Fir_Ylw.Aly_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_015000_PSCR.Slvr.Fir_Dkn.g.Rp_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_016000_PSCR.Slvr.Fir_Tlkn.g.Bts.2_h.264_Original_Highest</b>	Silver Fir Media Night1-Ambulanceandshooting.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_017000_PSCR.Slvr.Fir_Blry.Amblnce_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_018000_PSCR.Slvr.Fir_Lng.Frtrck_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_019000_PSCR.Slvr.Fir_Ldr.Extnd_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_020000_PSCR.Slvr.Fir_Frmn.W.Axe_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_021000_PSCR.Slvr.Fir_Lky.Hose_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_022000_PSCR.Slvr.Fir_Engn.76_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_023000_PSCR.Slvr.Fir_Engn.36_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_024000_PSCR.Slvr.Fir_Grp.Hdl_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_025000_PSCR.Slvr.Fir_Stretcher_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_026000_PSCR.Slvr.Fir_Yng.Frmn_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_027000_PSCR.Slvr.Fir_Wkng.Frmn_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_028000_PSCR.Slvr.Fir_Wet.Lense_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_029000_PSCR.Slvr.Fir_Btl.Chf_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_030000_PSCR.Slvr.Fir_Stdng.Grđ_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_031000_PSCR.Slvr.Fir_Disperse_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_032000_PSCR.Slvr.Fir_Decouple_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_033000_PSCR.Slvr.Fir_Drng.Hose_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_034000_PSCR.Slvr.Fir_Hose.Drp_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_035000_PSCR.Slvr.Fir_Cptn.Cairo_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_036000_PSCR.Slvr.Fir_On.The.Ldr_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_037000_PSCR.Slvr.Fir_Hose.Rtrct_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_038000_PSCR.Slvr.Fir_Bts.On.The.Grnd_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_039000_PSCR.Slvr.Fir_Wet.Lvs_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_040000_PSCR.Slvr.Fir_Stck.Hose_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_041000_PSCR.Slvr.Fir_Eng n.76.Lvng_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_042000_PSCR.Slvr.Fir_Hgh wy.Rn_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_043000_PSCR.Slvr.Fir_Hgh wy.Undrps_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_044000_PSCR.Slvr.Fir_Und r.Bridg_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_045000_PSCR.Slvr.Fir_Crs.Undr.Brdg_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_046000_PSCR.Slvr.Fir_Wet.Strt_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_047000_PSCR.Slvr.Fir_Ovr ps.Fnc_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_048000_PSCR.Slvr.Fir_Sdwlk.Pdl.1_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_049000_PSCR.Slvr.Fir_Sdwlk.Pdl.2_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_050000_PSCR.Slvr.Fir_AmbInce.32_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_051000_PSCR.Slvr.Fir_Whlchr.205_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_052000_PSCR.Slvr.Fir_Engn.13_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_053000_PSCR.Slvr.Fir_Frgh t.Trk_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_054000_PSCR.Slvr.Fir_Box.Trk_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_055000_PSCR.Slvr.Fir_Toll.Rd_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_056000_PSCR.Slvr.Fir_14.Ft.Brdg_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_057000_PSCR.Slvr.Fir_Rear.Vw_h.264_Original_Highest</b>	Silver Fir Media Rain.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_058000_PSCR.Slvr.Fir_Strtlght_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_059000_PSCR.Slvr.Fir_Plstc.Twn_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_060000_PSCR.Slvr.Fir_Snowy.Cty.Sdwlk_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_061000_PSCR.Slvr.Fir_Bodega_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_062000_PSCR.Slvr.Fir_Grn.Lght_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_063000_PSCR.Slvr.Fir_PlntR.Box_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_064000_PSCR.Slvr.Fir_Taxi_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_065000_PSCR.Slvr.Fir_US.Flag_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_066000_PSCR.Slvr.Fir_Snow.Drp_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_067000_PSCR.Slvr.Fir_Tree.Brncs_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_068000_PSCR.Slvr.Fir_Snow.Srfc_h.264_Original_Highest</b>	Silver Fir Media Snow.mp4	Produced by Silver Fir Media. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_069000_WideEye_Bdy.Srf_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment04.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_070000_WideEye_Cpl.Wlk_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment01.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_071000_WideEye_Gldn.Srfr_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment01.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_072000_WideEye_Isld.Bch_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment04.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_073000_WideEye_Kds.Ply_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment04.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_074000_WideEye_Lngbrd_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment02.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_075000_WideEye_Rock.Cove_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment03.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_076000_WideEye_Snd.Rppls_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment02.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_077000_WideEye_Sndy.Bch_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment01.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_078000_WideEye_Sea.Cliffs_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment03.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_079000_WideEye_Seabrd_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment01.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_080000_WideEye_Snst.Waves_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment01.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_081000_WideEye_Undertoe_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment03.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_082000_WideEye_Wave.Crs_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment03.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_083000_WideEye_Waves.Brkg_h.264_Original_Highest</b>	WideEye_Waves Beach_Segment01.avi	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_084000_SpinFilms_Brks_h.264_Original_Highest</b>	Raceway.mov	Produced by WideEye. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_085000_SpinFilms_Burnout_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_086000_SpinFilms_Fcs.Sht_h.264_Original_Highest</b>	Preview_Termites_Rain.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_087000_SpinFilms_Frnt.S.Trn_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
<b>VCRDCI_088000_SpinFilms_Hd.to.Hd_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_089000_SpinFilms_Mrchng.Army.2_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_090000_SpinFilms_Mrchng.Army_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_091000_SpinFilms_Mossy.Rck_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_092000_SpinFilms_Moto.Burnout_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_093000_SpinFilms_Mvng.Shot_h.264_Original_Highest</b>	Preview_Termites_Rain.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_094000_SpinFilms_Mscl.Cars_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_095000_SpinFilms_Nmbr.3_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_096000_SpinFilms_Rn.off.Rf_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_097000_SpinFilms_Rdcr_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_098000_SpinFilms_S.Trn_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_099000_SpinFilms_Snst.Drag_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_100000_SpinFilms_Sprbike.Drag_h.264_Original_Highest</b>	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_101000_SpinFilms_Termites.Log.2_h.264_Original_Highest</b>	Preview_Termites_Rain.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
<b>VCRDCI_102000_SpinFilms_Termites.Log_h.264_Original_Highest</b>	Preview_Termites_Rain.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.



Scene File Name	Original File Name	Publication Terms
VCRDCI_103000_SpinFilms_Trns.Spnn g_h.264_Original_Highest	Raceway.mov	Produced by SpinFilms. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_104000_PSCR.EMT.Riot_Pl ce.Int.1_h.264_Original_Highest	PoliceInterview_01.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_105000_PSCR.EMT.Riot_Pr sn.Riot.1_h.264_Original_Highest	PrisonRiot_01.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_106000_PSCR.EMT.Riot_Pr sn.Riot.2_h.264_Original_Highest	PrisonRiot_02.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_107000_PSCR.EMT.Riot_Te le.med.2_h.264_Original_Highest	Telemedicine_02.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_108000_PSCR.EMT.Riot_Te le.med.3_h.264_Original_Highest	Telemedicine_03.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_109000_PSCR.EMT.Riot_Te le.med.5_h.264_Original_Highest	Telemedicine_05.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_110000_PSCR.EMT.Riot_Te le.med.8_h.264_Original_Highest	Telemedicine_08.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_111000_HDTV.SRC_Aspn. Wlk_h.264_Original_Highest	AspenWalk_8bit.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_112000_HDTV.SRC_Bldr.Z oom_h.264_Original_Highest	BoulderZoom_8bit.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_113000_BigRabbit_Intro_h.2 64_Original_Highest	broadcast_BGRrevisedopen_o riginal.mp4	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_114000_BigRabbit_Outtro_h .264_Original_Highest	broadcast_BGRrevisedopen_o riginal_1.mp4	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_115000_5G.Challenge_SAvs NSA_h.264_Original_Highest	5G_Challenge_SA vs NSA_SUB_Final.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_116000_5G.Challenge_Visio n_h.264_Original_Highest.mp4	5G_Challenge_VISION_SUB _FINAL.mp4	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_117000_2013.NTIA.4k_Actvt y.in.Park_h.264_Original_Highest	Acitvty in the Park.mpeg	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.

<b>Scene File Name</b>	<b>Original File Name</b>	<b>Publication Terms</b>
VCRDCI_118000_2013.NTIA.4k_Busy.City_h.264_Original_Highest	Busy City.mpeg	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_119000_2013.NTIA.4k_Meadow_h.264_Original_Highest	Childs Play.mpeg	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_120000_2013.NTIA.4k_Spiraling_h.264_Original_Highest	Childs Play.mpeg	Produced by ITS. NTIA/ITS has the rights to redistribute this footage for R&D purposes.
VCRDCI_121000_4k.from.SVT_Cty.Pan_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_122000_4k.from.SVT_Pigeon.Eye_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_123000_4k.from.SVT_Strltd.Dcks_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_124000_4k.from.SVT_Trnstn_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_125000_4k.from.SVT_Flyover_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_126000_4k.from.SVT_Flyover2_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_127000_4k.from.SVT_Mrthn_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_128000_4k.from.SVT_Dnc.Party_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_129000_4k.from.SVT_Dsspntmnt_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes
VCRDCI_130000_4k.from.SVT_Estate_h.264_Original_Highest	SVT_1080p50_8bitYUV.avi	Donated to CDVL. NTIA/ITS has the right to redistribute this footage for R&D purposes

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15. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.) This memorandum provides technical details of the VCRDCI dataset. This dataset was designed similarly to a video quality subjective experiment, but the VMAF metric was used to create simulated subjective data. The VCRDCI dataset contains 130 scenes that have been rescaled to eight resolutions and compressed into 10 variable bitrates with three codecs. The goals are (1) to provide a dataset for developing no-reference (NR) metrics that track the image quality of commonly used codecs, (2) to understand characteristics of videos that have complex interactions with video codecs, (3) to understand the relationship between public safety use cases and acceptable levels of compression, and (4) to develop a metric that responds strongly to the effects of video compression.		
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