

DELL EMC ISILON AND AUTODESK FLAME

UNDERSTANDING THE REQUIREMENTS OF SUPPORTING AUTODESK FLAME WITH DELL EMC ISILON AND ONEFS 8.1

Abstract

This document examines the deployment, configuration and optimisation of Dell EMC Isilon and Autodesk Flame.

It is intended that architects and system integrators use this document as a guide to both understanding and configuring potential performance enhancing optimisations when using Dell EMC Isilon with Autodesk Flame.

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Table of Contents

DELL EMC ISILON AND AUTODESK FLAME	1
TABLE OF CONTENTS	2
VERSION CONTROL	4
BASIC CONFIGURATION GUIDE	5
EXECUTIVE SUMMARY	5
BACKGROUND READING	5
OVERVIEW OF PRODUCT AND MARKET	6
OVERVIEW OF APPLICATION ARCHITECTURE	6
STONE AND WIRE	6
MANAGED AND UNMANAGED MEDIA	6
OVERVIEW OF APPLICATION DEMANDS	7
OVERVIEW OF THE BENEFITS OF USING DELL EMC ISILON	7
OVERVIEW OF FILE TYPES	8
METADATA FILES	8
MEDIA FILES	8
Image Sequence	9
Clip Based Media	10
Compression	10
Performance Metrics	10
THROUGHPUT	11
LATENCY	13
CONFIGURATION GUIDELINES	14
BASIC CONFIGURATION	14
Workstation Specification	14
Isilon and OneFS Version	14
Network Connectivity	14
Filesharing Configuration	14
Application Configuration	15
ADVANCED CONFIGURATION AND OPTIMISATIONS	15
ONEFS OPTIMISATIONS	16

Metadata Read/Write Acceleration	16
Overview	16
Enabling	16
Streaming Mode	16
Overview	16
Operation	17
Enabling	17
Filename Pre-Fetch	17
Overview	17
Operation	17
Enabling	18
Further Information	18
APPLICATION OPTIMISATIONS	19
COLD DATA	19
EXAMPLE SYSTEM ARCHITECTURE AND TEST ENVIRONMENT	20
APPLICATION TESTING	21
TEST PLANS	21
Throughput Test	21
Optimisation	22
Data Analysis	27
Number of Video Tracks	27
Application Specific Throughput	31
Latency and Stability Test	33
Optimisation	34
SCALING AND MODELLING	35
CONCLUSION	36

Version Control

<i>Date</i>	<i>Version</i>	<i>Notes</i>
<i>January 2018</i>	1.0	Initial Release

Basic Configuration Guide

Executive Summary

This document outlines the interaction between Dell EMC Isilon and Autodesk Flame, and provides guidance on achieving the best performance. The document goes on to describe the Autodesk Qualification Programme, and the steps taken to achieve qualification for Isilon storage.

This document is based on work undertaken with Isilon H600 and F800 All Flash, OneFS 8.1, and Autodesk Flame 2017 and 2018.

This document does not make specific recommendations regarding component hardware, and nor does it make any claims regarding specific performance.

Background Reading

This document assumes knowledge of the portfolio of Dell EMC Isilon - including H600, F800 and A2000. More information is available at:

<https://www.emc.com/collateral/software/data-sheet/h10541-ds-isilon-platform.pdf>

For more background information on working with uncompressed media and image sequences, this document should be read in conjunction with “Uncompressed High-Resolution Workflows with Dell EMC Isilon” H16818.

<https://www.emc.com/collateral/whitepaper/h16818-wp-uncompressed-high-resolution-workflows-isilon.pdf>

Overview of product and market

Autodesk Flame is an editing, compositing, 3D effects and finishing tool for cinema, television and commercial production. It's a powerful application and is used by creative professionals to produce high quality on-screen 2D and 3D effects.

Autodesk Flame is normally deployed at post production facilities, integrated with on-premises infrastructure, and is very often used as part of a collaborative workflow.

Overview of Application Architecture

Stone and Wire

The Autodesk Flame application (along with other Autodesk Creative Finishing Applications) is architected around the proprietary concept of *Stone and Wire*. *Stone and Wire* is a layer that sits between the application and Isilon Scale-out NAS (or any other connected file system).

- *Stone* handles local media management on a workstation.
- *Wire* is designed to enable the transfer of media between workstations over networks.

More information about *Stone and Wire* can be found at:

<http://help.autodesk.com/view/FLAME/2018/ENU/?guid=GUID-46FFCC84-43C5-4B07-9D64-717660F1536D>

Managed and Unmanaged Media

Within the Autodesk framework, a connected storage volume may be designated as a *Managed Partition*. Media that is stored on a *Managed Partition* is managed by *Stone*, and is said to be *Managed* media. Media not on the *Managed Partition*, and not managed by *Stone* is said to be *Unmanaged* media.

In simplified terms, *Unmanaged* media describes files that already exist on the storage, and that the application is pointed towards; whilst *Managed* media describes files that are created or processed in some way and then written to the storage by the application.

This document contains guidelines for configuring and using Isilon storage that are relevant both to *Managed* and *Unmanaged* media.

Overview of Application Demands

The demands of editing, compositing, 3D effects and finishing are high - particularly at high frame rates and resolutions - and consequently Autodesk Flame relies on a highly performant workstation, networking and storage infrastructure. When designing a system, architects will need to consider both quantitative and subjective requirements.

- Throughput
- Latency
- Demands of different codecs
- Scrubbing
- Multi-track
- Subjective “feel”

As part of the Autodesk qualification programme, the Dell T7910 Precision Workstation and both Dell EMC Isilon H600 and F800 Scale Out storage are qualified to support Autodesk Flame.

More information about the system requirements of Autodesk Flame can be found at:

<https://knowledge.autodesk.com/support/flame-products/learn-explore/caas/sfdcarticles/sfdcarticles/flame-sysreqs.html>

Overview of the benefits of using Dell EMC Isilon

The use of Dell EMC Isilon brings significant benefits to Autodesk Flame workflows and environments:

- Dell EMC Isilon is easily scalable - and can grow with your business.
- Silos of task-specific storage may be eliminated. It is possible to work directly from the centralised Isilon storage repository - with no requirement to move media around in a “push-pull” workflow.
- A single namespace may be maintained across tiers of storage - including performant Dell EMC Isilon H600 and F800, and (for example) file archive A2000.

Overview of File Types

Autodesk Flame may be used with a number of different file types:

- Metadata:
 - Action Only Formats
 - Sequence Exchange Formats
- Media:
 - Image Sequences
 - Clip Based Media
 - QuickTime clips
 - Media Exchange Format (MXF) clips
 - MP4 clips
 - Other Streaming Codecs

More information about file types and formats supported by Autodesk Flame can be found at:

<https://help.autodesk.com/view/FLAME/2018/ENU/?guid=GUID-982B4FA6-2DB9-4E0D-ABAA-6AC9FD64568C>

Each file type presents a different challenge to each part of the system, and the file types being used by the required workflow must be considered.

Metadata Files

Metadata and sequence information files are typically relatively small in size, but frequently updated. These files contain information about the sequences being created or manipulated. For example, such a file could contain information about which clips are used in a sequence, or information about how the colours should be corrected.

Because metadata and sequence information files are small, they should not present any meaningful contribution to throughput requirements. However, it is important to remember that the files will be frequently accessed and updated.

Media Files

Because of their large size, media files of encoded video are normally considered to represent the most important challenge to an Architect when designing systems to support creative applications. Video can be encoded for digital storage either as an Image Sequence, or as a self contained clip.

Image Sequence

An image sequence represents each frame of video with a separate file. The files for a sequence are stored in the same directory, have a fixed base name with a decimal or hexadecimal incrementing suffix. Autodesk Flame works with a number of different image sequence formats, including:

- DPX
- ARRI
- Open EXR

Different applications use different naming structures and standards within this form, but some illustrative examples for DPX sequences would be:

```
filebasename_scene-01_00056.dpx  
filebasename_scene-01_00057.dpx  
filebasename_scene-01_00058.dpx
```

```
filebasename_scene-05_0FC09.dpx  
filebasename_scene-05_0FC0A.dpx  
filebasename_scene-05_0FC0B.dpx
```

More information about these formats - including their respective strengths and use-cases - can be found at:

```
https://en.wikipedia.org/wiki/Digital\_Picture\_Exchange  
http://www.arri.com/camera/alexa/workflow/working\_with\_arriraw/arriraw/format/  
http://www.openexr.com  
https://en.wikipedia.org/wiki/OpenEXR
```

Clip Based Media

A Clip based media file represents an entire sequence of video frames (and additionally very often interleaved audio, timecode and metadata) in a single file on the storage. Autodesk Flame works with a number of different clip-based codecs, including:

- RED
- XAVC
- ProRes
- DNX

More information about these formats - including their respective strengths and use-cases - can be found at:

<http://www.red.com/learn/red-101/redcode-file-format>

<https://en.wikipedia.org/wiki/XAVC>

https://en.wikipedia.org/wiki/Apple_ProRes

<https://support.apple.com/HT202410>

https://en.wikipedia.org/wiki/Avid_DNxHD

<http://www.avid.com/products/avid-dnxhr-and-dnxhd>

Compression

Both image sequences and clip-based media may be compressed. Compression can yield benefits in required storage capacity and throughput, but can generate computational overhead and reduce the perceived visual and audio quality of the media.

Compression may be Loss-Less (where the exact original image data may be recovered), Lossy (where some image data is discarded in the compression process), or Visually Loss-Less (where some image data is discarded, but in a way that is not detectable by the human eye).

Performance Metrics

Users of Autodesk Flame - particularly Visual Effects Artists - normally require to work with image sequences (rather than clip based media), and commonly work with uncompressed material. Consequently, it's important that Architects design a full system that is able to support the high performance demands of these workflows.

Autodesk Flame media makes the highest demands of workstations, networking and storage in any implementation, and so systems must be architected to accommodate those performance requirements.

The two key system performance metrics that architects must consider when specifying storage solutions for Autodesk Flame are *throughput* and *latency*.

Throughput

Throughput performance can be considered to be a measure of the required *sustained* data transfer rate between the storage and the application. To sustain playback at the application layer, the system must be able to support at least the required throughput over an indeterminate duration.

There are five important factors that dictate the size (and consequent throughput requirements) of media files, and their impact on the demands of supporting systems:

- Frame Size
- Frame Rate
- Colour Depth
- Encoding Method
- Compression Method

Characteristic	Possible Value
Frame Size	SD, HD, 2K (DCI) UHD, 4K (DCI), 8K (DCI)
Frame Rate	24, 25, 30, 50, 60 Frames per Second
Colour Depth	10-bit (Standard Dynamic Range), 12-bit (High Dynamic Range), 16-bit (High Dynamic Range)
Encoding Method	Image Sequence or Clip-Based
Compression Method	Uncompressed, Lossless, Visually-Lossless, Lossy

Table 1: Characteristics of encoded media.

- HD - High Definition - typically used in television
- UHD - Ultra High Definition - typically used in television
- DCI - Digital Cinemas Initiatives - typically used in cinema

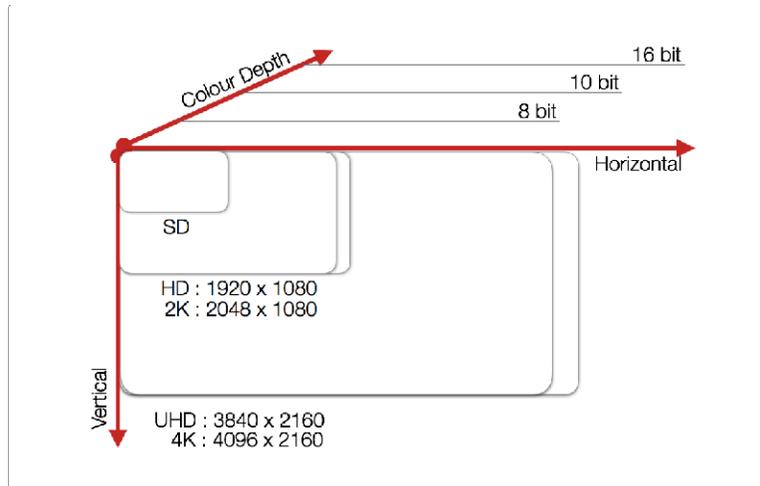


Fig 1: Illustration of relative frame sizes and colour depths.

As an example, listed below are the throughput requirements for 10-bit DPX sequences for a number of size and frame rates.

Name	Horizontal Size (Pixels)	Vertical Size (Pixels)	Frame Rate	Frame Byte Size (MBytes)	Throughput (MBytes per second)
HD	1920	1080	24fps	7.91	190
2K (DCI)	2048	1080	24fps	8.44	203
UHD	3840	2160	24fps	31.64	759
4K (DCI)	4096	2160	24fps	33.75	810
HD	1920	1080	60fps	7.91	475
2K (DCI)	2048	1080	60fps	8.44	506
UHD	3840	2160	60fps	31.64	1898
4K (DCI)	4096	2160	60fps	33.75	2025

Table 2: Throughput requirements for a selection of codecs and frame rates.

Latency

Latency performance can be considered to be a measure of the the required *instantaneous* data transfer rate. To offer a responsive experience at the application layer, the system must be able to deliver frames in a timely manner after they have been requested. One measure of latency is the *time to first byte* - how long it takes data to start flowing after it is requested by the application.

For image sequence workflows (where each frame of video is stored as a separate file), it is assumed that the application normally will request each frame sequentially whilst the preceding frame is being displayed. It follows therefore that for steady and sustained playback, each file must be requested and retrieved in less than the time for which each frame is displayed.

A summary of frame durations for a number of image sequence formats helps quantify the required latency targets.

Use Case	Frame Rate	Common Name	Horizontal Pixels	Vertical Pixels	Bit Depth	Channels	Frame Duration
Cinema	24fps	4K	4096	2160	10	YUV	42ms
PAL*	25fps	UHD	3840	2160	10	YUV	40ms
PAL*	50fps	UHD	3840	2160	10	YUV	20ms
NTSC*	30fps	UHD	3840	2160	10	YUV	33ms
NTSC*	60fps	UHD	3840	2160	10	YUV	17ms

Table 3: Frame Duration for a selection of formats and frame rates.

* The references to PAL and NTSC are used to indicate a loose alignment to legacy television standards and regional variations, and do not refer to any form of colour encoding, number of TV lines, or refresh rate.

Configuration Guidelines

Basic Configuration

Workstation Specification

Dell EMC recommends a suitably specified Dell Precision Workstation T7910 or later for use with Autodesk Flame. Specification and configuration of the workstation is outside of the scope of this document, but more information can be found at:

<https://blog.dell.com/en-us/dell-precision-welcomes-autodesk-flame-artists/>

Isilon and OneFS Version

Isilon H600 and F800 All Flash are both qualified to support Autodesk Flame environments. OneFS version 8.1 has been tested and qualified, and is required as a minimum. Later versions of OneFS may deliver equivalent or improved performance.

Network Connectivity

In order to achieve the throughputs required for typical Autodesk Flame workflows, it is required to configure a full 40GbE network - including Isilon storage, network infrastructure and client interface.

The system used whilst preparing this document was configured to use Jumbo Frames (MTU 9000).

The choice of Network Interface Card, and recommendations regarding network interface optimisation are dependant on the specific environment of each installation, and are therefore outside of the scope of this document.

Filesharing Configuration

In a collaborative environment, multiple users, using multiple workstations are required to access and share files. The Autodesk Flame application is hosted by CentOS Version 7. Standard guidance when using any distribution of Linux is to use the NFS filesharing protocol. It is assumed that the most appropriate variant of the protocol for most environments will be NFSv3.

The creation of an NFS Export on the Isilon storage cluster can be achieved using the administrative web interface of OneFS. Details are available at:

<https://www.emc.com/collateral/TechnicalDocument/docu84277.pdf>

Care should be taken to architect a OneFS NFS export and permissions strategy that accommodates the required workflow. NFS optimisation guidelines for connections from CentOS are dependant on the specific environment of each installation.

Configuring OneFS NFS exports and designing a permissions strategy is outside of the scope of this document.

Application Configuration

The Autodesk Flame application should have a base configuration according to guidance from Autodesk. In particular, the file access settings for the application should be configured to use NFS exports from Isilon storage:

- Managed Partition
- Unmanaged Partition
- Stone
- Wire

<https://knowledge.autodesk.com/support/flame-products/troubleshooting/caas/CloudHelp/cloudhelp/2017/ENU/Flame-SoftwareInstall/files/GUID-94F58DA2-A496-4614-8FCF-E4FD87F926A1-htm.html>

Advanced Configuration and Optimisations

When working with high performance applications such as Autodesk Flame, it is important to consider optimisations for the entire system, and the mutual interactions of those optimisations. Attention in particular should be given to optimisations for:

- OneFS - The Isilon storage cluster.
- Application - The Flame application itself.
- Infrastructure - The system as a whole, including networking and operating systems.

OneFS Optimisations

Architects should consider three key optimisations for OneFS when deploying in an Autodesk Flame environment.

- Metadata Read/Write Acceleration
- Streaming Mode
- Filename Pre-Fetch

Metadata Read/Write Acceleration

Overview

File access performance can in some workflows be optimised by enabling Metadata read/write acceleration. When enabled, this optimisation sees OneFS use SSDs for reading and writing filesystem metadata - which can improve access time and reduce latency. Where all underlying storage units are SSD - as in the case of Isilon F800 All Flash - then this is not a meaningful or required optimisation.

Enabling

Metadata read/write optimisation can be enabled as a File Pool Policy at the OneFS Web User Interface. More information and guidance is available in published documentation:

http://doc.isilon.com/onefs/8.1.0/help/en-us/index.html#ifs_c_ssd_pools.html

Streaming Mode

Overview

Streaming performance of OneFS can be optimised by enabling Streaming Mode at the file pool, or at the directory level. Streaming performance is important when playing media linearly - for example when playing a video sequence in a time line.

Consideration should be given to other workflows hosted in the same pool or directory before enabling Streaming mode. Best performance for all workflows on a single cluster might be achieved by selectively enabling Streaming Mode on a limited number of directories.

Operation

Streaming Mode optimises two behaviours of OneFS to deliver increased streaming performance:

- Data is striped across more underlying storage units (disc drives or SSDs).
- Data is prefetched aggressively.

Enabling

Streaming mode can be enabled as a File Pool Policy at the OneFS Web User Interface. More information and guidance is available in published documentation:

```
http://doc.isilon.com/onefs/8.1.0/help/en-us/index.html#ifs\_t\_configure\_default\_io\_optimization\_settings.html
```

```
http://doc.isilon.com/onefs/8.1.0/help/en-us/index.html#ifs\_t\_modify\_file\_and\_directory\_properties.html
```

It should be noted that when Filename Pre-Fetch (outlined below) is also required and enabled, there is an interaction between the two optimisations - which must be considered when configuring.

Filename Pre-Fetch

Overview

For image sequences, cluster-wide Filename Pre-Fetch can be enabled to optimise the streaming performance of OneFS when working with image sequences. Consideration should be given to other workflows hosted on the same cluster, and the impact of possible *false fetches* (where resources are used pre-fetching files that are not ever requested by the client) should be evaluated.

Operation

Filename Pre-Fetch enables a performance optimisation by detecting when image sequences are requested by a client. When a sequence is detected, OneFS will pre-fetch files from the underlying storage units (disc drives or SSDs) before they are requested.

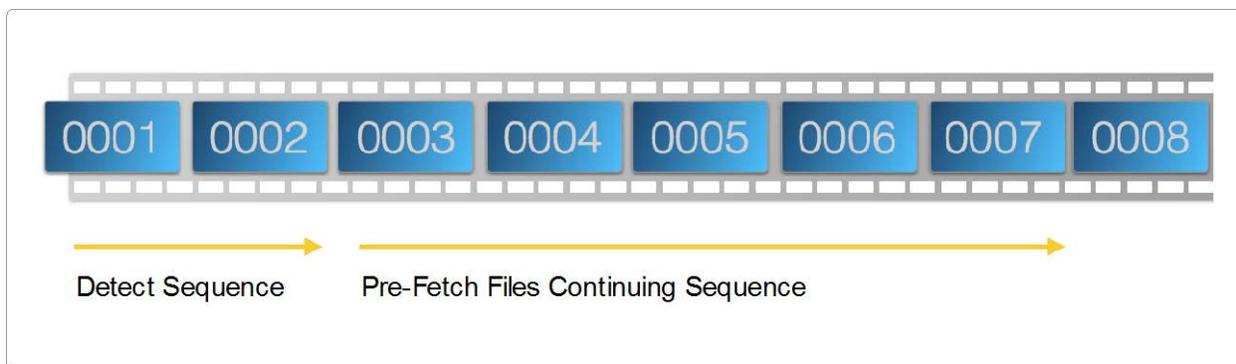


fig 2: Illustration of Filename Pre-Fetch. Note, this diagram does not indicate the actual algorithm.

The Filename Pre-Fetch algorithm is optimised to detect image sequences with either decimal or hexadecimal filename numerical increments.

Enabling

Filename Pre-Fetch can be enabled across the cluster at the command line of OneFS. A detailed overview and configuration guide is available at:

<http://www.emc.com/collateral/whitepaper/h16951-wp-isilon-file-name-pre-fetch.pdf>

Further Information

For detailed guidance on File Pool Policies and data layout and access strategies, check:

<https://www.emc.com/collateral/hardware/white-papers/h10719-isilon-onefs-technical-overview-wp.pdf>

Detailed guidance on using the command line to make administrative changes is available at:

<https://www.emc.com/collateral/TechnicalDocument/docu84280.pdf>

Detailed guidance on using the web interface to make administrative changes is available at:

<https://www.emc.com/collateral/TechnicalDocument/docu84277.pdf>

Application Optimisations

Overall performance, and the quality of the *Autodesk Flame Experience* can be greatly enhanced by optimising the application to take full advantage of the power of Isilon and OneFS.

Application optimisations are configured by setting Autodesk Flame Environment Variables. The optimal settings are dependent on the application version and the wider infrastructure, and so to avoid out-of-date information and inappropriate guidance they are not included in this document.

For more information, please contact Dell EMC Isilon Support, referencing Knowledge Base article 517079

Cold Data

Whilst the optimisations of Streaming Mode and Filename Pre-Fetch can enable performance and usability improvements, care must be taken to consider overall system performance when dealing with *Cold Data*.

Cold Data is data or media that is requested by the application but that is not cached or pre-staged in any part of the environment by the application, the client operating system, or the storage.

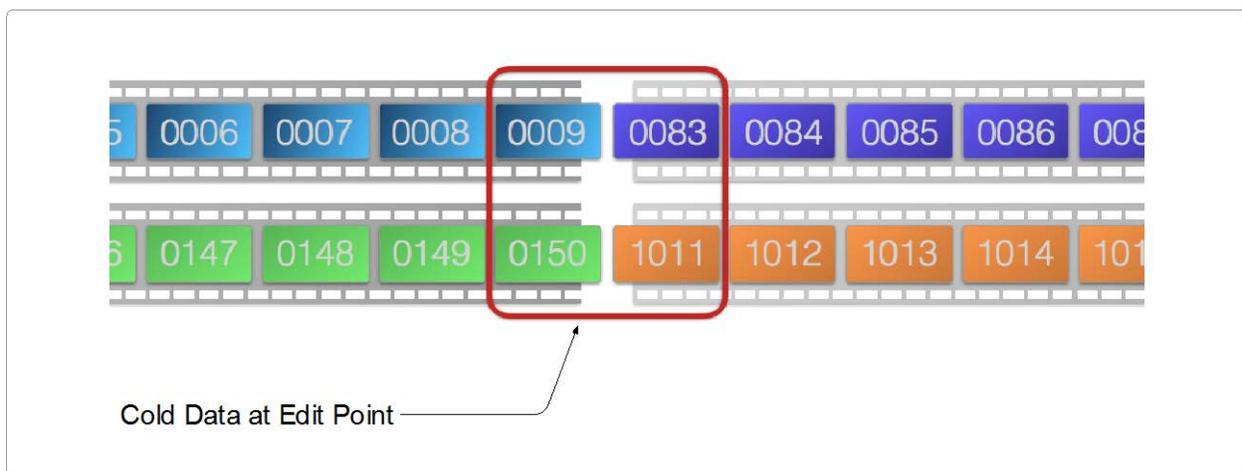


Fig 3: Cold Data at an Edit Point

Cold data may be requested when the application requests media that is out of sequence, or otherwise unexpected – for example, at an edit point on a timeline.

Example System Architecture and Test Environment

The information presented in this document is based on findings made when working with a basic architecture of client, network and Dell EMC Isilon F800 or H600. This document is not intended to detail a particular architecture. Component parts from other vendors are noted for reference, and a recommendation or preference should not be implied.

- Storage
 - Isilon F800 or H600.
 - OneFS 8.1.
- Client Workstation.
 - Dell Precision Workstation T7910.
 - Qualified Broadcast Video Output card - AJA Kona4.
 - Qualified GPU - NVidia M6000.
 - 40GbE Network Adapter - ATTO.
 - CentOS 7 Operating System.
- Networking.
 - 40GbE Network Switch.
 - Flat Network Topology.

The test work and findings outlined in this document are focussed on playback workflows (reading data from storage), and not on acquisition (writing data to storage). In most real-world workflows, Autodesk Flame is used to manipulate media that has already been captured.

The testing environment used to generate the data for this document comprised a single workstation, connected to a Dell EMC Isilon F800 or H600. Real-world collaborative environments will comprise a number of connected workstations.

- The demonstrated performance improvements for optimisations are relative - and so may be considered to scale across a number of connected workstations.
- The information contained in this document may be used in conjunction with separately published generic performance data to to predict the number of workstations that may be supported.

Application Testing

The Autodesk Qualification Programme outlines a suite of tests and benchmarks that are designed to examine, measure and qualify a storage platform. The tests characterise a number of workflows and multiple media types. The aim of the tests is to capture the quality of a user's *Autodesk Flame Experience*, and compare it to that of a reference architecture.

For a storage platform to be qualified, its performance metrics must support the quality of the user's *Autodesk Flame Experience*. Dell EMC Isilon has been tested with, and is qualified to use with Autodesk Flame 2017 and 2018. Future versions of Autodesk Flame will be tested as they are released.

Full details of the Qualification Programme are available from Autodesk.

Test Plans

The Autodesk Qualification Programme is divided into two main parts:

- Part One is designed to test the raw throughput that a storage system can support.
- Part Two is designed to test the stability of that throughput and the latency characteristics of the storage.

The Qualification Programme test suite focuses on the image sequence and clip-based codecs:

- DPX
- ARRI
- Open EXR
- RED
- XAVC
- ProRes
- DNX

Throughput Test

The raw throughput capability of a storage system is tested using the *Play All Frames* feature of Autodesk Flame. With this feature enabled, the application will play every frame in a timeline sequence as fast as possible - with no reference to the specified frame rate. On completion, the application will report the achieved *Effective Frame Rate*. Higher Effective Frame Rates indicate a higher storage throughput capability.

For each test, Autodesk publish a reference benchmark *Effective Frame Rate*. Autodesk provide guidance that a system that can achieve an *Effective Frame Rate* within five frames per second of the benchmark will support an acceptable *Autodesk Flame Experience*.

More information about the *Play All Frames* feature of Autodesk Flame is available at:

<https://knowledge.autodesk.com/support/flame-products/learn-explore/caas/CloudHelp/cloudhelp/2018/ENU/Flame-PlaynigBackMedia/files/GUID-5818A154-76BE-45E2-8AE4-943324F259C0-htm.html>

By measuring the *Effective Frame Rate* at which the application can consume media delivered by the storage, the throughput test reveals the application-specific performance capability of the storage. This is a more valuable reference than a measure based on generic performance testing tools, because it takes into account the detail of the specific demands and characteristics of the application.

The information gathered in the *Effective Frame Rate* tests can be processed in one of two ways, and then interpreted to show meaningful and comparable statistics.

- Use the benchmarks to test optimisations
- Calculate number of supported video tracks
- Calculate application specific throughput

Optimisation

The *Play all Frames* test is repeated for each codec type, and a number of different frame resolutions. For each test, the *Effective Frame Rates* shown in this document have been normalised. The reference benchmark published by Autodesk has been normalised to 100, and then the calculated normalising factor has been applied to the observed performance for each test.

Normalising the *Effective Frame Rates* makes comparisons between different test types much clearer, and allows for variations in test material in the future.

As an illustration: if the reference benchmark provided by Autodesk is an *Effective Frame Rate* of 39.9 frames per second:

- The benchmark would be normalised to 100.
- The guidance threshold of 34.9 frames per second would be normalised to 87.5.

- An example observed performance of 38.5 frames per second would be normalised to 96.5.

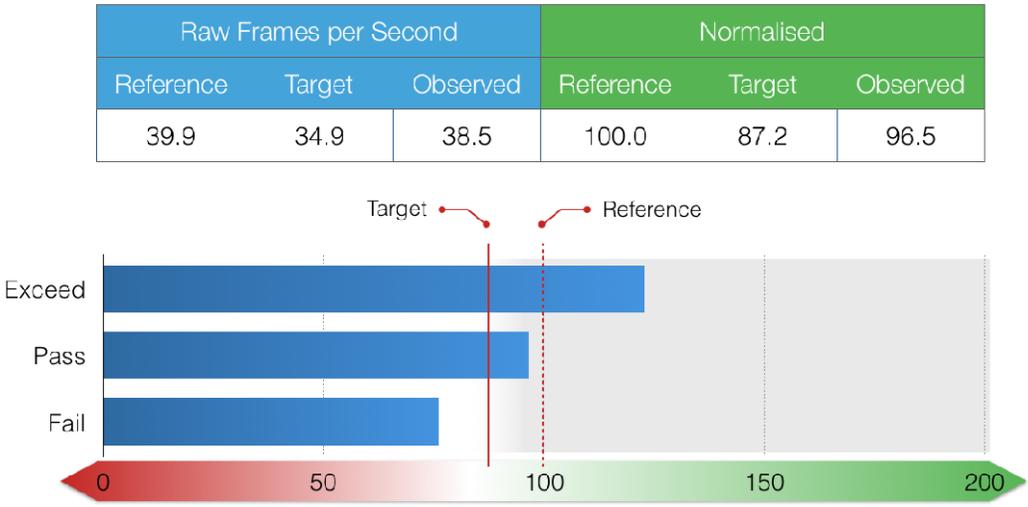


Figure 4: Illustration of example normalised data.

In this illustrative example, the Observed Performance exceeds the benchmark for the particular codec being scrutinised, and therefore the storage would support the required *Autodesk Flame Experience*.

In order to test different optimisations, all throughput tests were conducted under each of four scenarios:

- **“Out of the Box”** - with only the minimal base optimisations of *metadata read/write acceleration* and *Streaming Mode* applied to OneFS, and no optimisations applied at the application layer.
- **Filename Pre-Fetch** enabled at the cluster, for enhanced streaming performance of image sequences.
- *Filename Pre-Fetch* enabled at the cluster, with application layer optimisations enabled at the client.
- Application layer optimisations enabled, but with *Filename Pre-Fetch* **disabled**.

The following table shows the normalised *Effective Frame Rate* for a number of codec types, resolutions, and frame rates - compared to the benchmark and targets for a satisfactory *Autodesk Flame Experience*. The data for these tests was generated using a Dell EMC Isilon H600. A higher *Effective Frame Rate* is better.

Codec Type	Normalised Reference	Normalised Target	Out-of-the-Box	Filename Pre-Fetch	Filename Pre-Fetch & Application Optimisations	Application Optimisations Only
DPX HD	100	87.2	96.49	167.92	189.72	138.35
DPX 4K	100	87.2	89.94	129.18	143.06	134.61
RED 4K	100	87.2	105.67	105.67	105.44	105.44
ARRI 2K	100	87.2	60.23	80.68	100.68	90.23
ARRI 3K	100	87.2	59.07	73.58	102.25	91.71
Open EXR u 2K	100	87.2	97.36	143.01	175.46	136.41
Open EXR zip 2K	100	87.2	86.21	86.78	93.39	91.09
Open EXR u 4K	100	87.2	69.23	96.26	109.01	99.56
XAVC UHD	100	87.2	80.84	83.37	123.02	125.11
ProRes 422HQ HD	100	87.2	82.93	86.34	108.62	105.04
ProRes 422HQ 4K	100	87.2	76.62	78.94	113.89	108.33
DNX HD	100	87.2	79.74	87.07	101.75	100.44
DNX HR	100	87.2	80.2	78.16	110.92	92.49

Table 4: Throughput requirements for a selection of codecs and frame rates.

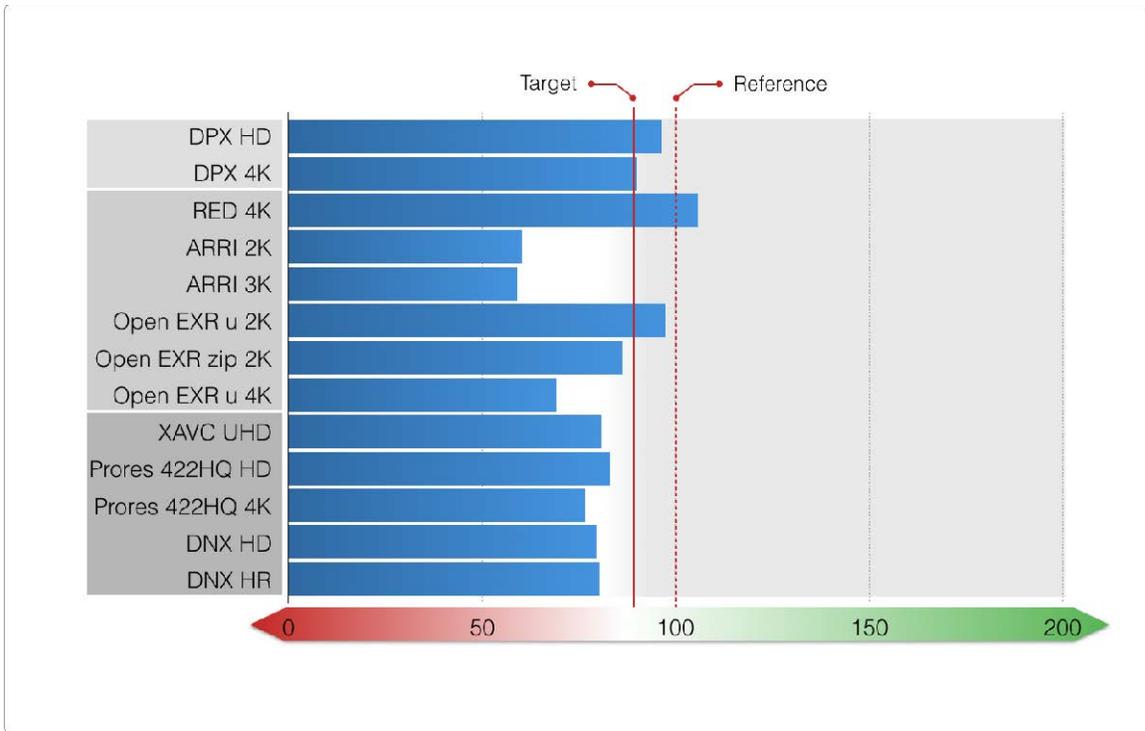


Chart 1 (Table 4): Normalised Effective Frame Rate with standard (Out of the Box) optimisations only.

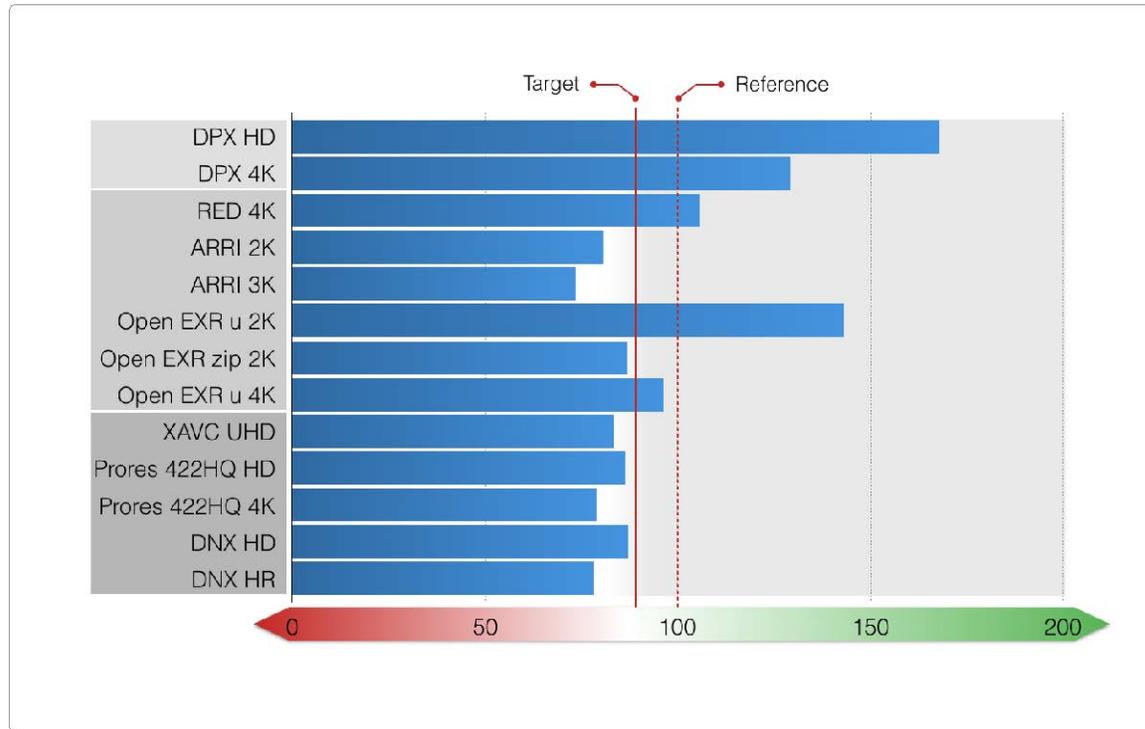


Chart 2 (Table 4): Normalised Effective Frame Rate with Filename Pre-Fetch enabled.

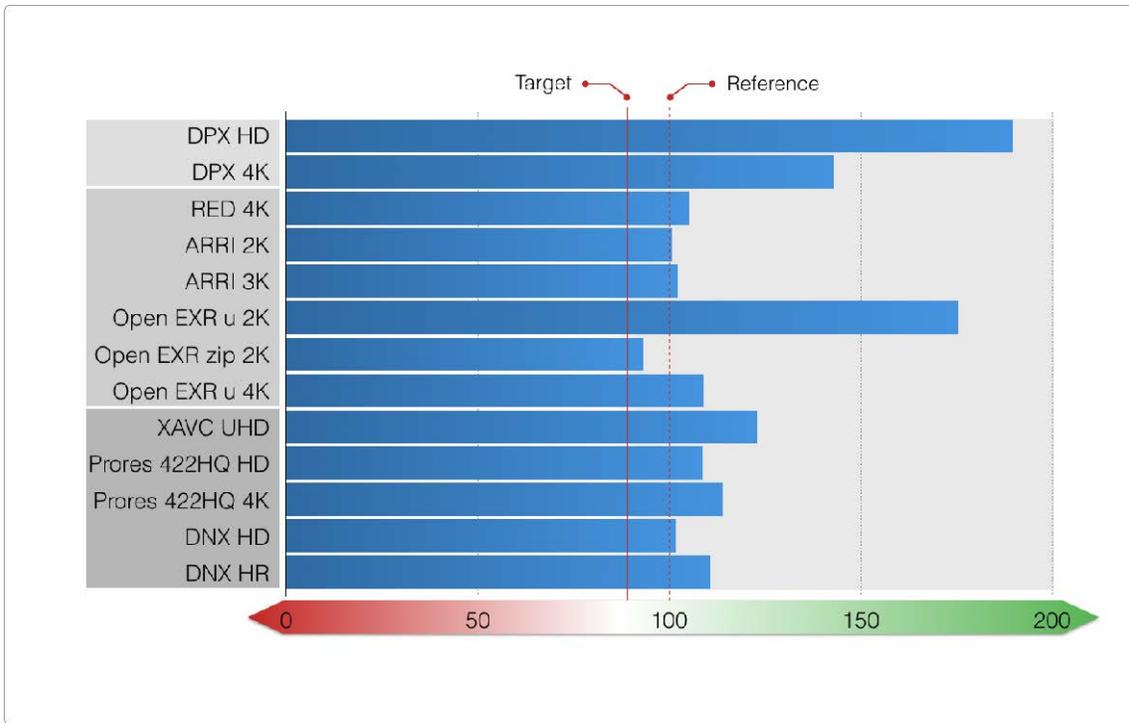


Chart 3 (Table 4): Normalised Effective Frame Rate with Filename Pre-Fetch enabled, and Application layer optimisations applied.

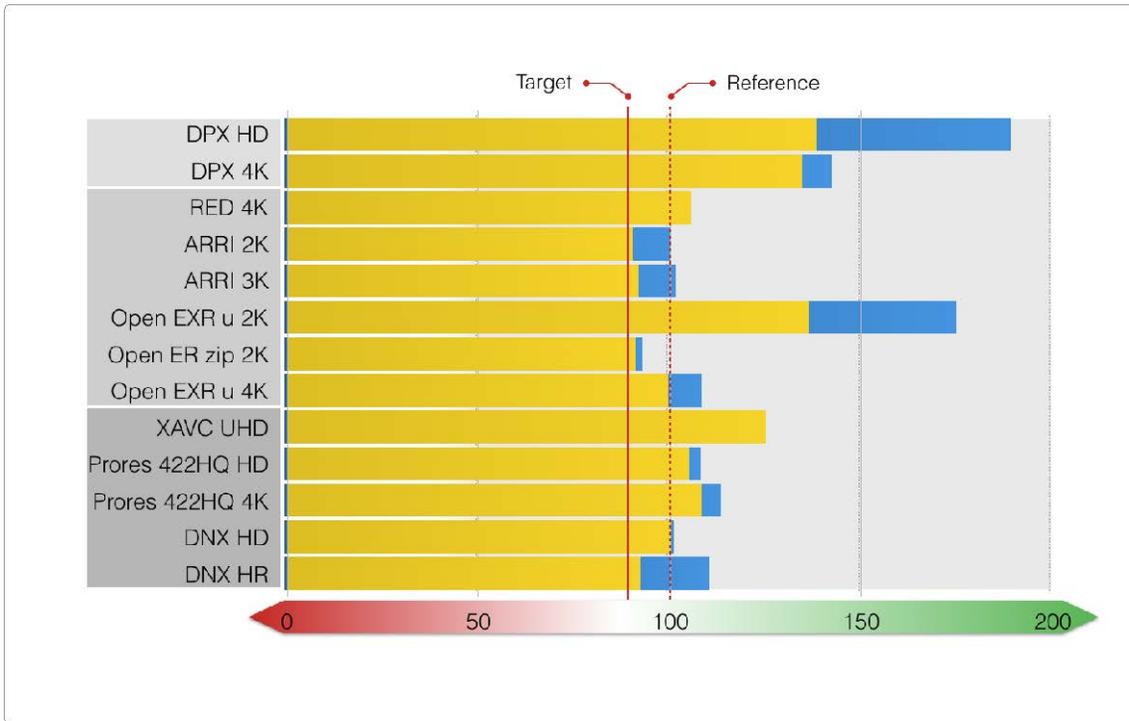


Chart 4 (Table 4): Normalised Effective Frame Rate (highlighted) Filename Pre-Fetch **DIS**abled, and Application layer optimisations applied.

For the test environment being used, the test results show that for all codec types, Dell EMC Isilon delivers the performance required for a satisfactory *Autodesk Flame Experience*.

- For the test environment being used, a satisfactory *Autodesk Flame Experience* may be achieved without applying any advanced optimisations.
- The best performance is achieved when both application and OneFS optimisations applied.
- Different optimisations affect the *Autodesk Flame Experience* in different ways. For example, enabling Filename Pre-Fetch provides a performance improvement for image sequences, and not for clip based media.

Care should be taken to consider the benefits and impact of optimisations, and to apply the optimisations that are the most appropriate to the workflow and the environment.

Data Analysis

Number of Video Tracks

If you can measure the achievable *Effective Frame Rate* for a given resolution and codec type, it is possible to calculate the number of video tracks at the target frame rate that could be supported by a single workstation on a single NFS connection to one node of the Isilon cluster. For example, if the tests demonstrate that a 24fps sequence can be played at an *Effective Frame Rate* of 61fps, then it follows that the system could support two simultaneous video tracks to a single workstation on a single NFS connection when played at the target frame rate.

The following table shows the measured *Effective Frame Rate* for a number of codec types, resolutions, frame rates and colour depths - alongside the Calculated Achievable Video Track Count. The data for these tests was generated using a Dell EMC Isilon F800.

Codec	Resolution	Frame Rate	Colour Depth	Measured Effective Frame Rate	Calculated Achievable Video Track Count
DPX	1920x1080	23.98fps	10-bit	292.1	12
DPX	4096x2160	23.98fps	10-bit	75.1	3
RED R3D	4096x2104	24.00fps	12-bit u	60.9	2
ARRI RAW	2880x1620	23.98fps	12-bit u	94.9	3
ARRI RAW	3414x2202	24.00fps	12-bit u	61.4	2
Open EXR	2048x1556	23.98fps	16-bit fp	121.1	5
Open EXR	4096x2160	24.00fps	16-bit fp	43.2	1
Sony XAVC	3840x2160	23.98fps	10-bit	150.4	6
ProRes 422HQ	1920x1080	23.98fps	10-bit	608.8	25
ProRes 422HQ	4096x2160	23.98fps	10-bit	227.1	9
DNXHD	1920x1080	23.98fps	10-bit	532.1	22
DNXHR	4096x2160	23.98fps	10-bit	174	7

Table 5: Calculated Achievable Video Track Count for a selection of codecs and frame rates.

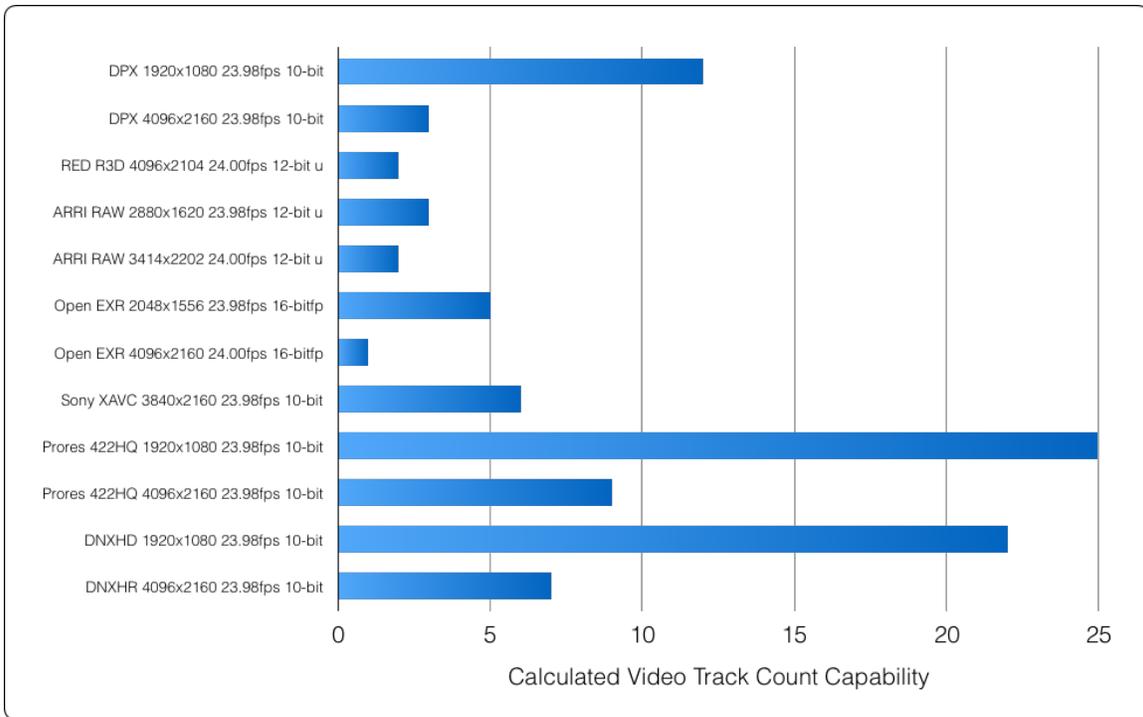


Chart 5: Calculated Achievable Video Track Count for a selection of codecs and frame rates.

The measured *Effective Frame Rate* can also be used to calculate the Achievable Video Track Count for the tested codec types at a number of different frame rates. For example, if the tests demonstrate that the *Effective Frame Rate* capability for a certain resolution and codec type is 54 frames per second (fps), then it follows that the system would be able to support two tracks at either 24 or 25 fps, or one track at 30 fps.

The following table shows the measured *Effective Frame Rate* for a number of codec types, resolutions, frame rates and colour depths - alongside the Calculated Achievable Video Track Count for a selection of frame rates. The data for these tests was generated using a Dell EMC Isilon F800.

Codec	Resolution	Colour Depth	Measured Effective Frame Rate	Calculated Achievable Video Track Count			
				24fps	30fps	50fps	60fps
DPX	1920x1080	10-bit	292.1	12	9	5	4
DPX	4096x2160	10-bit	75.1	3	2	1	1
RED R3D	4096x2104	12-bit u	60.9	2	2	1	1
ARRI RAW	2880x1620	12-bit u	94.9	3	3	1	1
ARRI RAW	3414x2202	12-bit u	61.4	2	2	1	1
Open EXR	2048x1556	16-bit fp	121.1	5	4	2	2
Open EXR	4096x2160	16-bit fp	43.2	1	1	n/a	n/a
Sony XAVC	3840x2160	10-bit	150.4	6	5	3	2
ProRes 422HQ	1920x1080	10-bit	608.8	25	20	12	10
Prores 422HQ	4096x2160	10-bit	227.1	9	7	4	3
DNXHD	1920x1080	10-bit	532.1	22	17	10	8
DNXHR	4096x2160	10-bit	174	7	5	3	2

Table 6: Calculated Achievable Video Track Count for a selection of codecs and frame rates.

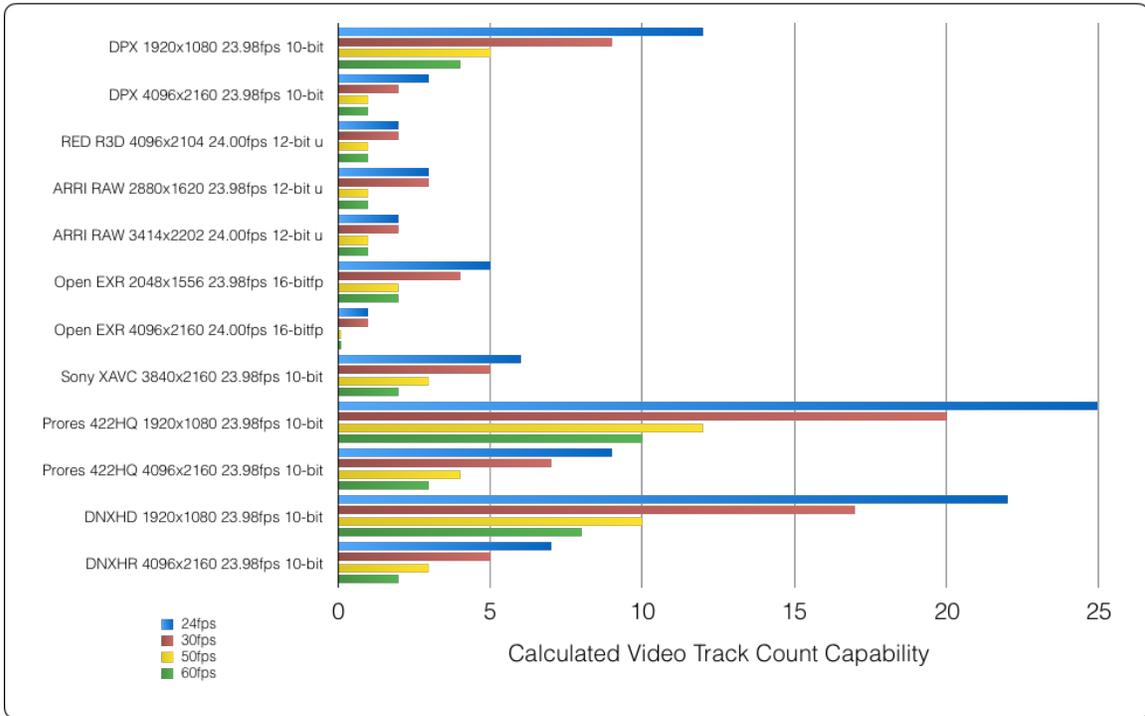


Chart 6: Calculated Achievable Video Track Count for a selection of codecs and frame rates.

The data reveals that more video tracks of some codec types can be accommodated by the system than others - and this should not be a surprise. Some codec types have larger files - demanding a higher throughput - and others are more complex and computationally expensive to decode.

When the *Effective Frame Rate* is interpreted in this way to show the number of video tracks that can be accommodated, it's possible to make an informed decision regarding which formats and workflows can be supported by the system.

Application Specific Throughput

An alternative approach to analysing the data takes the *Effective Frame Rate* measured in frames per second, and factors the size of the media files being used for testing. In this way, it is possible to calculate the application-specific single stream throughput performance expressed as a data rate (Bytes per Second).

For example, if each frame of a DPX sequence has a file size of 32MB, and tests demonstrate that the maximum achievable *Effective Frame Rate* for that sequence is 64

frames per second, then it follows that the application-specific throughput performance would be 2048MB/s (2GB/s).

(32 MB per frame x 64 frames per second) / 1024 = 2GB per second

The following table shows the measured *Effective Frame Rate* for a number of codec types, resolutions, frame rates and colour depths - alongside the calculated *Application-Specific Throughput* in MB per second.

Codec	Resolution	Frame Rate	Colour Depth	Frame Size MB	Measured Effective Frame Rate	Calculated Application-Specific Throughput MB/s
DPX	1920x1080	23.98fps	10-bit	8	292.1	2336.8
DPX	4096x2160	23.98fps	10-bit	34	75.1	2553.4
RED R3D	4096x2104	24.00fps	12-bit u	n/a	60.9	n/a
ARRI RAW	2880x1620	23.98fps	12-bit u	6.7	94.9	635.83
ARRI RAW	3414x2202	24.00fps	12-bit u	11	61.4	675.4
Open EXR	2048x1556	23.98fps	16-bit fp	18	121.1	2179.8
Open EXR	4096x2160	24.00fps	16-bit fp	51	43.2	2203.2
Sony XAVC	3840x2160	23.98fps	10-bit	n/a	150.4	n/a
ProRes 422HQ	1920x1080	23.98fps	10-bit	n/a	608.8	n/a
ProRes 422HQ	4096x2160	23.98fps	10-bit	n/a	227.1	n/a
DNXHD	1920x1080	23.98fps	10-bit	n/a	532.1	n/a
DNXHR	4096x2160	23.98fps	10-bit	n/a	174	n/a

Table 7: Calculated Application Specific Throughput for a selection of codecs and frame rates.

The *Application-Specific Throughput* is a useful and important measure, because it reveals the performance of the system that is available to the application - taking into

account any throughput-reducing challenges. It is therefore a more valuable and meaningful measure than generic performance metrics.

The *Application-Specific Throughput* may be different to generic performance metrics for the platform, and so the data may be used to calculate an offset or correction factor that could be used to more accurately specify storage provision. That step is outside of the scope of this document.

The data reveals an approximate maximum single stream *Application-Specific Throughput* for this test environment of around 2.2GB/s. Also revealed is that for one codec type in particular (Open EXR), the *Application-Specific Throughput* is measured to be somewhat lower. This may be because decoding files of this type is computationally expensive, and the limiting factor for performance.

Latency and Stability Test

The stability and latency performance of the storage is tested using debug tools that are built in to Autodesk Flame. The tools monitor and report where any frames are dropped by the application during playback of a timeline sequence.

The test measures stability by checking that the storage system can deliver media to the application consistently at the required rate. In other words it's a measure of the instantaneous throughput that can be delivered, and a check that it is at least as good as (and preferably better than) that required by the frame rate.

The latency performance of the storage system is tested by measuring its ability to deliver data consistently in a timely manner.

- A *Timely Manner* means *in time for the media to be used by the application*. If a frame of video cannot be delivered to the application in a timely manner, then that frame cannot be displayed in a playback sequence - and so it will be dropped by the application. The exact period of time that is considered to be *timely* varies according to the frame rate of the video sequence.
- A video playback application may tolerate a limited amount of temporal variance in the timely delivery of media, depending on the size and strategy of any read-ahead or pre-caching algorithm.

During normal playback of a timeline sequence, the application may drop a small number of frames - and this should not be a cause for concern. However, if during the Latency and Stability Test, the application drops a significant number of frames, then this can be an indicator that either the storage system or supporting architecture cannot support that workflow. The Autodesk Qualification Programme includes a benchmark

frame drop count that is considered acceptable and within specification for a number of scenarios.

Optimisation

Different strategies for optimising for Latency and Stability were considered, including:

- Metadata read/write acceleration
- Filename Pre-Fetch
- Application layer optimisations

Application optimisations are configured by setting Autodesk Flame Environment Variables. The optimal settings are dependent on the application version and the wider infrastructure, and so to avoid out-of-date information and inappropriate guidance they are not included in this document.

For more information, please contact Dell EMC Isilon Support, referencing Knowledge Base article 517079

Whilst the optimisations may enable performance and usability improvements, care must be taken to consider overall system performance when dealing with *Cold Data*. *Cold Data* is data or media that is requested by the application but that is not cached or pre-staged in any part of the environment by the application, the client operating system, or the storage.

The consideration of *Cold Data* is particularly relevant for Latency testing - and has an impact on the subjective responsiveness and “feel” of the application.

The tests revealed that:

- When using Dell EMC Isilon F800, no particular optimisation yielded a significant performance benefit.
- When using Dell EMC Isilon H600, the greatest improvements in Latency and Stability were achieved when application layer optimisations were applied.

These findings are consistent with expectation. Dell EMC Isilon F800 is an all-flash architecture with superior latency characteristics. It is significant to note that a satisfactory *Autodesk Flame Experience* may also be achieved with a suitably configured Dell EMC Isilon H600.

Scaling and Modelling

It is important to reiterate that the testing environment used to generate the data for this document comprised a single workstation, connected to a Dell EMC Isilon F800 or H600, and that real-world collaborative environments will comprise a number of connected workstations.

The *Application-Specific Throughput* is a useful and important measure, because it reveals the performance of the system that is available to the application - taking into account any throughput-reducing challenges. It is therefore a more valuable and meaningful measure than generic performance metrics.

The tests conducted in the preparation of this document reveal an approximate maximum single stream *Application-Specific Throughput* of around 2.2GB/s.

The *Application-Specific Throughput* may be used to calculate an offset or correction factor that may be used in conjunction with generic performance and sizing information, and be used to more accurately specify storage provision. That step is outside of the scope of this document.

Conclusion

The use of Dell EMC Isilon H600 or F800 brings significant benefits to Autodesk Flame workflows and environments - with particular improvements to workflow and productivity brought about by:

- The elimination of silos of task-specific storage.
- The provision of a single namespace across tiers of storage - including (for example) file archive with a Dell EMC Isilon A2000 cluster.