DCI Digital Cinema Initiatives, LLC

DCI STATEMENT ON TECHNOLOGY EVOLUTION IN DIGITAL CINEMA

Approved 29 March 2019

Digital Cinema Initiatives, LLC, Member Representatives Committee

Introduction

Since its founding in 2002, a primary purpose for Digital Cinema Initiatives, LLC (DCI) has been to establish and document voluntary specifications for an open architecture for digital cinema, facilitating high-quality cinema-going experiences for audiences while ensuring interoperability and content security. DCI recognizes that the benefits of Digital Cinema cannot be fully realized without industry-wide specifications, and the confidence of all parties involved in the practice of Digital Cinema that their products and services are interoperable and compatible with each other. DCI's guiding principles continue to be these three essential areas: Security, Interoperability and Quality.

During the development process of the Digital Cinema System Specification (DCSS), DCI heavily relied on collaboration with industry experts, filmmakers, distributors, exhibitors, and equipment manufacturers. Working together with the industry in evaluating emerging technologies remains a high priority for DCI and we continue to seek input from industry partners on the evolution of the Digital Cinema space. DCI thanks everyone who has been involved in this ongoing process.

Technology Evolution

The Digital Cinema industry continues to evolve, promising much improved experiences for audiences. Studios represent Filmmakers who are attracted to new and innovative tools and formats that promote and enhance their storytelling options. Filmmakers are interested in a consistent and superior presentation that preserves their creative intent.

Over the past years, a number of new and exciting d-cinema technologies have emerged. DCI has expended considerable effort studying these technologies in great detail. There are three areas of new technology that are particularly relevant for the Digital Cinema industry, including:

- Enhancements in projection systems (Phosphor & RGB Lasers, Light Steering)
- Introduction of new display systems (Direct View Displays)
- New imaging formats such as High Dynamic Range (HDR)

With the emergence of these new technologies, DCI has received requests from industry members for guidance and perspective. Focusing on the three primary areas - security, interoperability, and quality - DCI has evaluated these technologies with an eye to their impact on the Digital Cinema ecosystem, releasing two *draft* specifications on HDR Digital Cinema Masters and Direct View Displays in November 2018.[1]

These documents are partially a response to the requests to DCI for advice and recommendations and offer the perspective of DCI and its member studios. They are purposely released as *draft* documents looking for comments and observations from the industry.

Document Structure

On a high level, these documents describe two different sets of requirements.

The *High Dynamic Range D-Cinema Addendum* provides a definition for a new HDR Digital Cinema Master. This HDR Master constitutes a *new creative expression* available to our filmmakers. The HDR specification is, by design, technology-independent and aims to provide a sufficiently differentiated experience to consumers such that they can easily recognize the improvement.

The *Direct View Display D-Cinema Addendum* addresses performance & security characteristics for Direct View Displays. Since the current DCSS was designed with projection systems in mind, DCI recognizes that different requirements are necessary for Direct View Displays that complement those of projection systems.

The intention of these documents, as shown in *Figure 1*, is for any DCI-compliant projection and/or direct view display system to be able to play back traditional Digital Cinema Packages (DCPs). And at the same time, future HDR DCPs will be playable on HDR-capable projection and/or direct view display systems.

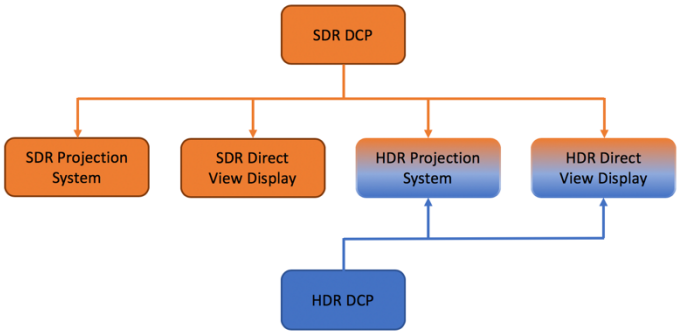

Figure 1: DCP Playback is display technology independent

[1] See https://www.dcimovies.com/drafts/DCI-DRAFT-HDR-D-Cinema-Addendum_v09_2018-1116.pdf and https://www.dcimovies.com/drafts/DCI-DRAFT-Direct-View-Display-D-Cinema-Addendum_v09_2018-1116.pdf

It is also worth highlighting that a critical feature of the HDR system developed by DCI is one of creative expression. An HDR DCP need not exercise the entire range of brightness offered by the HDR specification. Despite the peak luminance that an HDR system is capable of, *the brightness or darkness of each shot of a movie is always up to the filmmaker.* It is not up to the HDR projector or display, which simply provides the full range of capabilities. DCI seeks to ensure that the headroom required to reproduce a filmmaker's creative vision exists, whether that be the darkness of a cave, a candle, a car's headlights, a meteor, or sunlight spilling through a window.

Draft Specification Development Process

The release of both draft documents was the result of a multi-year development process which included substantial research, testing efforts, and cross-collaboration with industry experts to understand the benefits, limitations, and trade-offs of the various technologies. DCI carefully examined the landscape of technologies available both today and on the horizon. DCI is very grateful to the many contributions from industry members in sharing their knowledge, which enabled DCI members to make more informed decisions in developing these specifications.

High Dynamic Range Evaluation

In 2017, DCI conducted viewing sessions that evaluated different image characteristics with improved contrast ratios.[2] The viewing sessions utilized short clips of existing theatrical content that were chosen based on their suitability for image comparison testing in a higher dynamic range projection environment. The image attributes that were tested are summarized in *Table 1* below.

Peak Luminance	Minimum Black Level	Maximum Contrast Ratio
48 nits	0.024 nits	2,000:1
100 nits	0.020 nits	5,000:1
100 nits	0.010 nits	10,000:1
100 nits	0.005 nits	20,000:1
100 nits	0.002 nits	50,000:1
100 nits	0.001 nits	100,000:1
100 nits	0.0005 nits	200,000:1

Table 1: Image attributes during DCI viewing session

The luminance adjustment used to simulate different contrast performance for the image evaluation are shown in the plot below in *Figure 2*:

[2] See https://www.dcimovies.com/announcements/DCI-Image-Evaluation-Summary_20180511.pdf

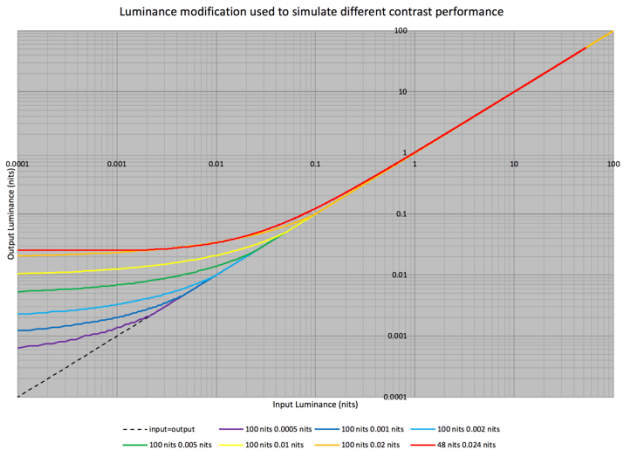

Figure 2: Luminance modifications simulating different contrast performance

DCI also performed ambient lighting tests in a few select commercial theaters to confirm the feasibility of the tested black levels in commercial installations. While there is a great variability of the ambient lighting conditions in the market, it was possible to confirm that the desired black levels are possible, and already achieved by many exhibitors today.

The viewing audience was comprised of creative and technical talent from each of the DCI member studios, industry experts, and non-expert viewers. In total, more than 100 individuals participated in the subjective comparisons that were performed as a double-blind test. The results of this testing showed a clear correlation between higher contrast, peak luminance, and an improved viewing experience, as shown in *Figure 3*. However, DCI concluded that additional research into peak luminance levels beyond 100 nits was needed before a final decision could be made.

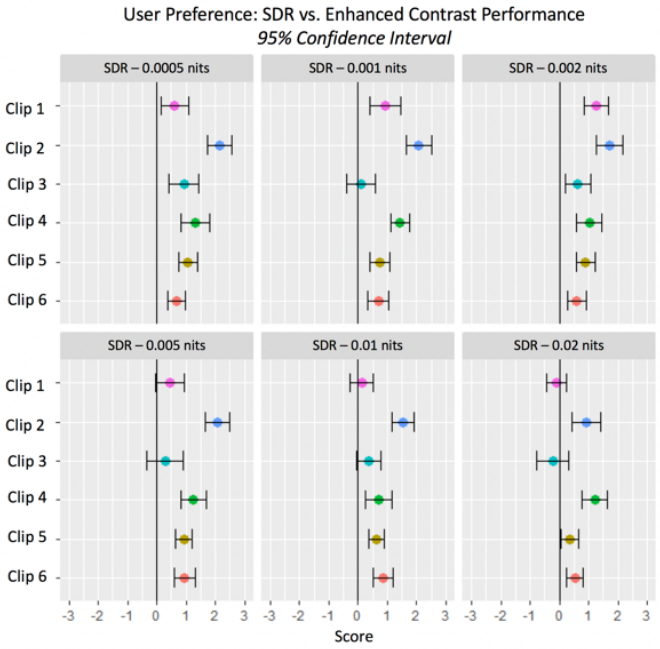

Figure 3: User preference results from viewing session

DCI continued to study display and projection devices with peak luminance capabilities that exceeded those available at the time of the initial tests in an effort to determine parameters that would constitute a truly differentiated HDR experience. This included many discussions with industry experts, critical image evaluation of various prototype systems, and consideration of technical papers presented at industry conferences.

Additionally, while recognizing that the theatrical experience will always be unique and fundamentally differentiated from the home, DCI members were able to leverage the experience they had gained working with creatives on the production of HDR home entertainment grades. This valuable experience gave the members direct feedback from filmmakers: how they view HDR, how they've come to use it, and how those uses vary from filmmaker to filmmaker.

Direct View Display Evaluation

After consultation with industry experts in the field of Direct View Displays, DCI released a *Memorandum Regarding Direct View Displays* in June 2018, outlining some of its proposed requirements.[3]

Subsequently, DCI performed detailed testing of various Direct View Display systems to understand their performance characteristics. DCI also spent many hours in face-to-face discussions with multiple equipment manufacturers and industry experts examining various parameters and soliciting feedback.

Request for Comments

The result of this multi-year specification development process is two documents that DCI released in November 2018:

- *Draft* High Dynamic Range D-Cinema Addendum
- *Draft* Direct View Display D-Cinema Addendum

These *draft* documents reflect all the research, analysis and discussion input received to date. DCI encourages feedback from industry members and asks interested parties to review these documents and provide comments to dci.info@dcimovies.com no later than May 31, 2019.

[3] See https://www.dcimovies.com/announcements/DCI-Memo-On-Direct-View-Displays_2108-0627.pdf