



THE NATIONAL ASSOCIATION
OF THEATRE OWNERS

To: All NATO Members
From: Michael Karagosian and Kendrick Macdowell
Date: July 27, 2005
Re: Release of DCI's Digital Cinema System Specification

The final DCI specification, scheduled for public circulation on Wednesday, July 27, 2005, can be reviewed at the following site:

<http://www.dcimovies.com>

The DCI specification is a significant achievement for rival studios, which fashioned a workable technical foundation for the competitive manufacture and distribution of digital cinema equipment. The DCI specification primarily addresses the distribution format and the security of studio content. DCI's work does not replace the work taking place in the SMPTE DC28 Technology Committee for Digital Cinema. Rather, DCI's effort is best viewed as significant input to the ongoing work within SMPTE DC28. However, the prospect that some equipment manufacturers will not await the final formal completion of the SMPTE standard makes DCI's achievement important for exhibition. The DCI specification, while incomplete and imperfect, gives exhibitors a useful standard for assessing the kind of equipment they ultimately install. DCI's final specification bears many marks of the steady constructive dialogue between DCI and the exhibition industry. In a few areas, exhibition will likely wish to supplement the DCI specifications.

The discussion below highlights the areas where DCI's work most affects the exhibition industry.

A) Theatre Operators Maintain Control of Theatre Operations

Throughout our work in both SMPTE and with DCI, our goal has been to retain the manner of doing business in a digital world as it exists today in the film world. Certain features of the digital format will inevitably differ from the film format. However, NATO has striven to ensure that such differences do not materially compromise exhibitors' control over their business.

Playlist definitions and division of responsibility

Exhibitors will retain control of their show presentations (the order of the show elements) and show schedules (the specific time for the show elements). The individual show elements, called "Compositions," may be logos, public service announcements, ads, trailers, or movies. Each show element generally must be a separate Composition—meaning, importantly for exhibition, that studios cannot, for example, combine a movie and a trailer (or a movie and an advertisement) into a single "Composition" and effectively force exhibitors to run the elements together.

Show presentations will be controlled by means of a Show Playlist. DCI did not define the interchange details of this list, leaving the door open for companies to implement proprietary versions. Server companies may view a proprietary Show Playlist as a sales tool. Without a standard interchange format for the Show Playlist, proprietary Show Playlists could mean that exhibitors must stick to one brand of equipment to provide interoperability among screen systems within the projection booth. To open up the market, NATO began an effort within SMPTE to define a standard interchange format for the Show Playlist.

Movement of shows between auditoriums

With a film projection system, moving a show from one screen to the next requires moving a platter of film. With a digital projection system, moving a show requires the transfer of the Show Playlist and the individual Compositions listed in the Show Playlist. Studios expect to encrypt trailers and movies, which means that the security keys must be available to play these on the target system.

Security keys by their nature are married to individual pieces of equipment. Each piece of equipment requires a different security key to play a Composition. We have approached this problem with the studios from several angles, and we have secured a verbal commitment from studios to send all of the keys necessary for a theatre complex to play content on any screen in the complex. This studio commitment is not a technical specification as such, and therefore does not appear in the DCI Specifications. However, on more than one occasion, studios have indicated publicly, and privately to vendors, that they intend to deliver all of the keys to a theatre complex. The seriousness with which we have treated this issue, coupled with our reliance upon the multiple assurances from studios, indicate that exhibitors will have the same latitude to play content on different screens as they enjoy today.

DCI has not defined how the distributors of security keys will learn which keys are needed for a given theatre complex. NATO proposed a tool called the Facility List, the concept of which was accepted by DCI members, and by the Security Ad Hoc Group within SMPTE DC28. The Facility List enables the

exhibitor to communicate to the key distributor which equipment in which complex will need security keys. The list is defined such that exhibitors remain in control of communicating which equipment is in each theatre complex, versus an alternative arrangement where key distributors would take responsibility for searching each complex for this information. DCI chose to leave the specification of the Facility List for exhibition to define.

In practice, even with a Facility List mechanism in place, exhibitors will face new challenges when replacing equipment. For newly installed or replacement equipment to play all of the movies in a theatre complex, you must obtain the specific keys from the key distributor targeted for the new equipment. Most studios expect future key distribution to be handled by their movie fulfillment company, such as Technicolor or Deluxe. These movie fulfillment companies must be prepared for rapid delivery of new keys when new or replacement equipment is installed.

Control of security logs

Studios want to review security logs as their primary method for confirming the performance and use of digital equipment. DCI's specification does not dictate who controls the shaping and sharing of these logs. We have insisted throughout the work of both SMPTE and DCI that any data created in the booth should belong to the exhibitor. Such log proprietorship is particularly important because security logs can be used to reconstruct business data, such as movie start times.

With this understanding, we worked closely with DCI to develop a security log specification that would allow exhibitors to select and filter which information to share. For example, exhibitors will be able to share security log data collected after business hours, and thereby build trust that their theatres are not used for pirate recordings. If exhibitors share data collected during normal hours of operation, they may select the shared information (such as the operational status of security equipment), and exclude sensitive data (such as security key requests related to a particular movie). Moreover, some filtering will often be necessary to avoid sharing data about one studio's movie with a different studio. Such selection and filtering software will need to be included in theatre management systems.

B) Promotes Compatibility and Interoperability

One of the most significant achievements of DCI's specification is its commitment to compatibility and interoperability—key themes sounded by exhibition throughout the process. Many exhibitors ruefully recall the fiasco of digital sound—and the duplicative devices theatres became obliged to carry to accommodate different incompatible systems. A significant inefficiency for digital sound, such incompatibility would cripple the

development of digital cinema systems. Moreover, defining standardized digital components ensures that several manufacturers may participate in the supply of digital equipment, thereby ensuring robust competition and avoiding product bottlenecks that give too much power to single manufacturers. While some work remains to be done for optimal compatibility and competition, DCI's achievement with respect to "single inventory content"—the phrase that generally describes the ability to distribute content in a single format with the assurance that it will play everywhere—is momentous, and summarized below.

Image representation

DCI specifies the SMPTE-defined DCDM for 2K and 4K images.

Audio representation

DCI specifies the Broadcast Wave format, but also calls for unspecified Dynamic Downmixing and Dynamic Range Control, leaving the door open for proprietary implementations.

Content compression

DCI specifies a specific application of JPEG2000 for 2K and 4K images, no compression for audio. (More on how JPEG2000 enables single-inventory for 2K and 4K in the next topic.)

Content encryption

DCI specifies a specific application of AES encryption with 128 bit keys.

Security Keys

DCI specifies RSA public key encryption for the encryption of content security keys, and the use of the Key Delivery Message (KDM) for communication of this key.

Forensic marking

DCI specifies that both audio and image be forensically marked when played in the theatre. Recent developments in forensic marking led to a significant change in DCI's approach to this technology. It is now expected that forensic marks will be "inserted" when the content is played in the theatre. The original technology for the mark will be selected by the content owner and the specific metadata for creating these marks will be created at the time of mastering. The goal is to have all exhibition systems use the same mark inserter, eliminating a potential source of premature equipment obsolescence.

Digital packaging

DCI specifies the SMPTE-defined MXF/XML packaging method, including a digital packing list.

Media format

DCI does not specify the media format. Hard drive delivery, for instance, only works if formatted for the machine that will read it (Windows, Linux, Mac).

While DCI has eliminated audio compression, it left the door open for proprietary audio through the mechanisms of downmixing and dynamic

range control. These issues have been raised by NATO in SMPTE, with the intent to pursue standards for these methods.

The issue of incompatible media format has yet to be solved by the Information Technology industry, and will not be solved by ours. However, this incompatibility should not burden exhibitors in the manner of digital sound in the 90s. Content distributors are expected to finance the installation of termination equipment for their delivery systems, much in the manner that telecommunication companies provide termination equipment for their lines. These termination systems should include readers for the distribution company's physical media, mitigating the media incompatibility problem.

C) High Quality Levels Capable of Exceeding both Film and the Home

Digital cinema is capable of achieving quality levels that exceed that of duplicated film, and capable of significantly exceeding that of the home. Image quality is associated with (generally in this order):

- Color space,
- Contrast,
- Resolution.

Many have been impressed with the current TI 2K projector. This technology comes close to matching the color space of film, and well exceeds the color space of conventional HDTV. Its contrast is not yet that of film, but has improved significantly over the years. In comparison to the home, it well exceeds that of conventional NTSC television, although this comparison may be less favorable as consumers switch to new high-contrast digital HDTV sets.

Resolution, however, is the one number that commands popular focus, and is easiest to market to consumers. In its studies, the ITU demonstrated that duplicated 35mm film has less resolution than HDTV (HDTV has an image resolution of 1920 x 1080 pixels). However, to differentiate the lower range of digital cinema from the consumer image format, DCI has specified a low end "2K" resolution maximizing at 2048 vertical lines by 1080 horizontal lines. An "upper-end" 4K resolution is also specified, maximizing at 4096 vertical lines by 2160 horizontal lines. While 2048x1080 is only slightly larger than the consumer HD 1920x1080 format, the 4K 4096x2160 format offers 4 times the number of pixels found in consumer HDTV.

While 4K is the goal, the technology today is only proven for 2K. Sony is demonstrating a 4K projector at trade shows, but the demonstration has yet to match the color space or contrast of the TI projector, making the Sony projector an under-performer visually. The Sony projector has yet to be tested in a busy, metropolitan cinema that operates many shows daily. Even if a 4K projector were available, it would need a 4K server. As of this writing, no vendor has a 4K server on the market, or even in demonstration. Sony,

notably, uses 4 servers to drive one projector in its trade show demonstrations. 4K technology is likely to be many years away from achieving theatre-level performance and operation.

To insure single-inventory content in a 2K / 4K world, DCI specified a standard compression technology capable of handling both sets of image resolutions in one data file. Using JPEG2000, a compliant server can play a 4K image to a 2K projector by extracting the 2K version of the image from the 4K image file. The specification of JPEG2000 and the specific application of it for single-inventory content distribution was a significant milestone in the DCI process.

D) Protects Against Movie Theft

DCI's specification devotes considerable detail – approximately half of the 160 page document – to describing the security performance of equipment in the projection booth. Nothing in this specification, however, will prevent camcorder piracy by customers. While several technologies have been demonstrated, no technology available today can successfully ensure sustained defeat of camcorder piracy. Thus, studios are leaning strongly on forensic marking, such that pirated copies can be traced to the location where the piracy occurred. Such information can be useful in learning patterns of theft that could lead to the capture of pirates. Forensic marking is required by DCI for both image and audio.

DCI's extensive security requirements will prevent piracy of the movie in its pure, high quality, digital form. In formulating this specification, we expressed concern that the complexity of the specified approach will lead to higher equipment costs and lower reliability. However, the consensus among DCI members appears to be that such complexity is necessary. Of particular concern to exhibitors are the conditions under which a dark screen will occur, which we call the "dark screen rules." These rules have undergone considerable changes over time, with substantial evolution toward NATO's viewpoint. The final specification provides for "dark screens" upon:

- Attempting to play the content at the wrong location;
- Attempting to play the content at the wrong date or time (i.e., outside the contractual engagement window);
- Attempting to use an unauthorized device (equipment is not accepted by the content owner); and
- The failure of, or tampering with, security equipment (including the failure of security logging equipment).

In early discussions with DCI, NATO supported the first two dark screen rules, in addition to a third dark screen rule for content that has been modified. Defining what constitutes modified content became a complex issue, and

sensing modified content at the equipment level proved burdensome. At DCI's suggestion, this third rule was removed.

Following substantial discussion about several additional rules, DCI narrowed its additional rules to the third and fourth rules above. Rule #3 states that an "unauthorized device" cannot be used, and clarifies it by adding the parenthetical "equipment is not accepted by the content owner." NATO attempted to modify this rule by asking that DCI remove the parenthetical statement, leaving the door open for a yet-to-be-defined certification process. However, the consensus among DCI's members was to retain the original wording.

NATO also objected to Rule #4. In general, failures in security processes such as opening a security key or decrypting content constitute a systemic failure, and naturally result in a dark screen. The same cannot be said for security logging, however. Again, the consensus among DCI's members was to retain this rule.

In pondering the extent to which these rules may be enforced, we quote DCI's "Notice" statement at the beginning of its specification: "Each DCI member company shall decide independently the extent to which it will utilize, or require adherence to, these specifications."