Associação Brasileira de Cinematografia

A Review of Digital Cinema

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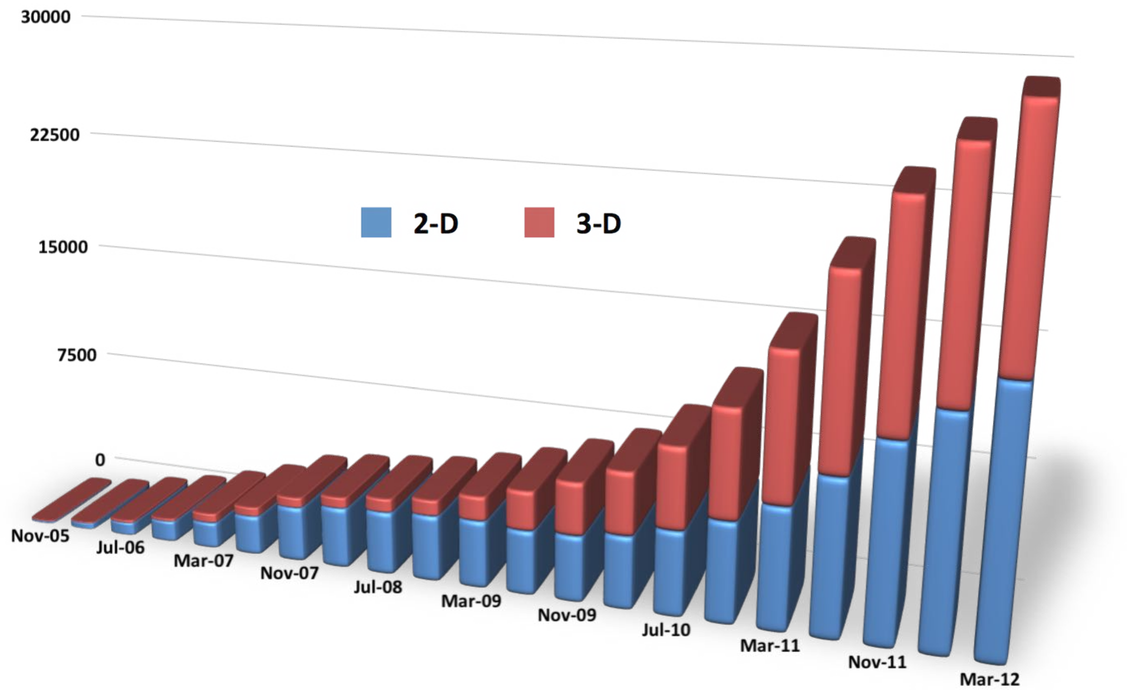
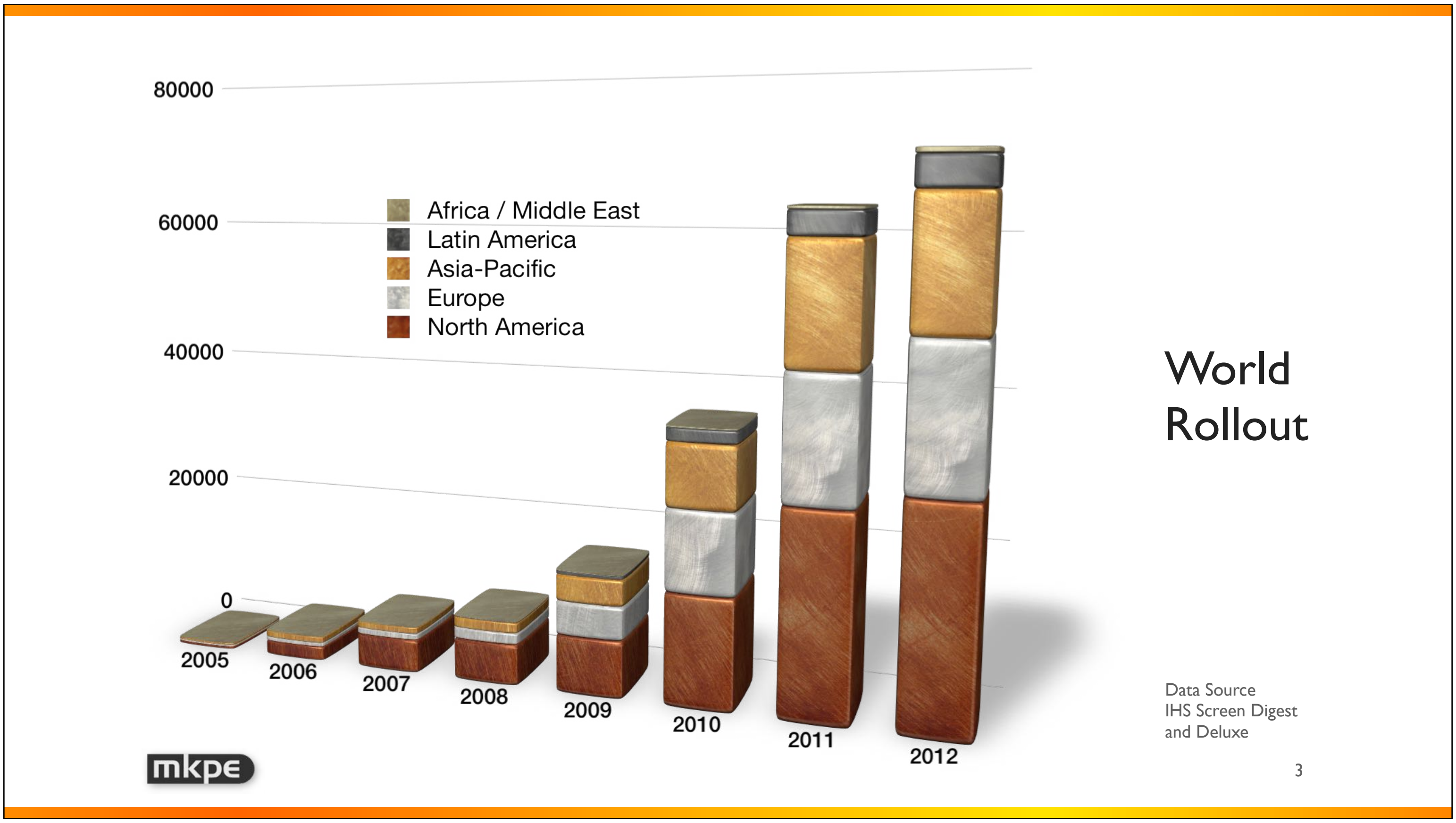


US Rollout

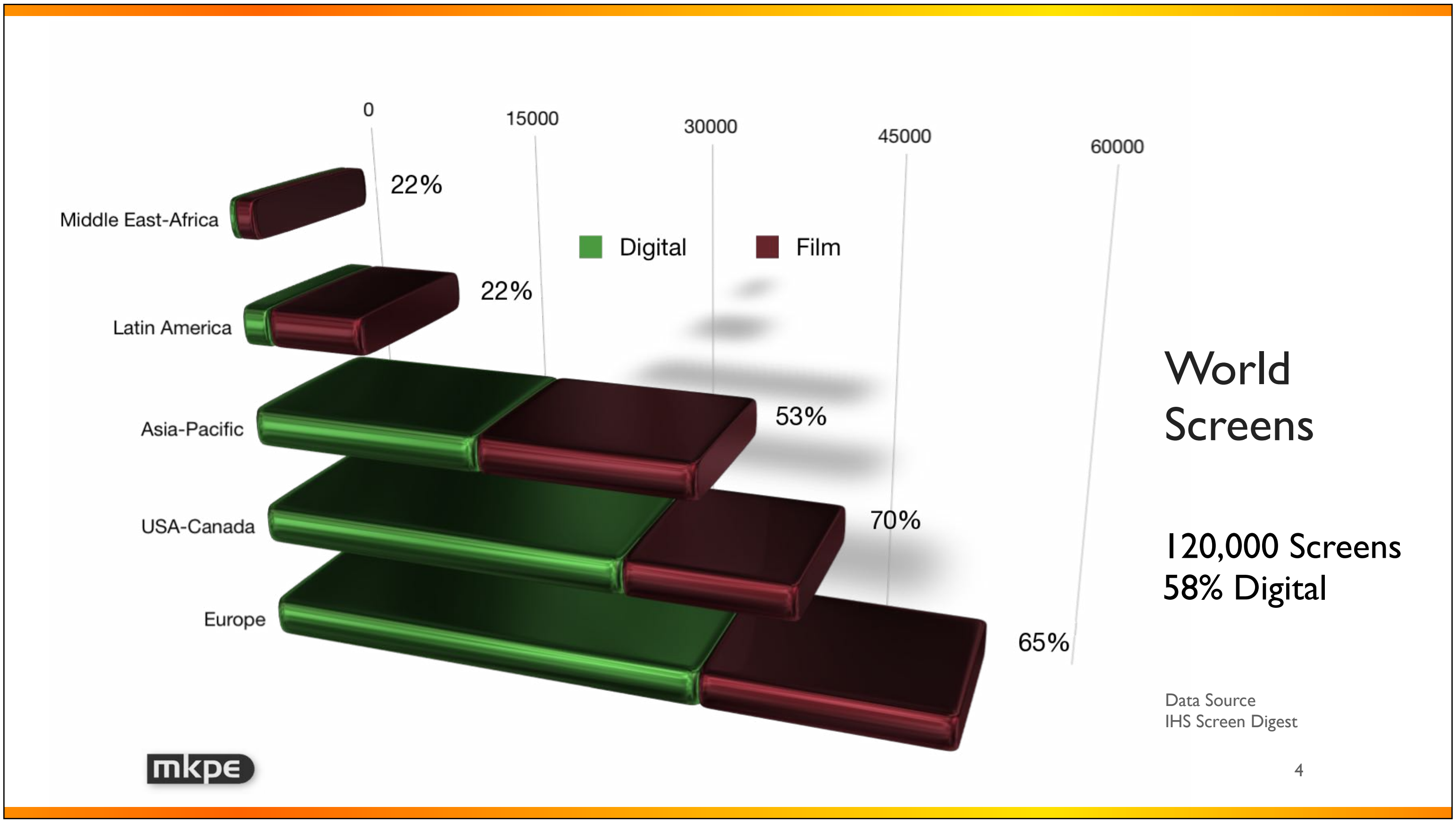
Data Source
Technicolor
and Deluxe

As of the end of March, approximately 28,000 digital projectors were installed in US cinemas. About 50% of these are 3-D. However, the 2-D digital screen count is growing.



Worldwide, 70,000 digital projectors have been installed. The counts are:
30,000 US and Canada
19,000 Europe
17,500 Asia-Pacific
2,500 Latin America

Notice that the growth in worldwide digital screens began to accelerate in 2009, as cinema owners anticipated the success of Avatar in 3-D. Even after Avatar, cinema owners continued to install digital projectors. I'll talk about why this happened in a bit.



There are around 120,000 cinema screens around the world, and approximately 58% of these are now digital. The percentages shown indicate the degree of digital conversion for each region.

Rollout Drivers

VPF

DCI Digital Cinema Initiatives, LLC

- **3-D** provides added value
- **Virtual Print Fees (VPFs)** subsidize the conversion of cinemas
- **DCI Specification** assures banks of the resale value of equipment

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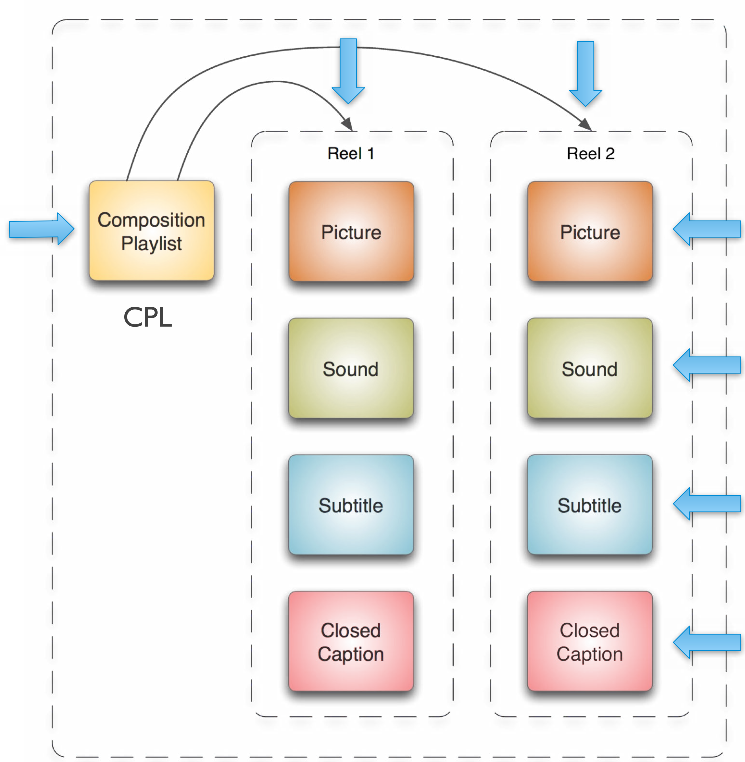
Noted earlier, the growth in worldwide digital screens began to accelerate in 2009, as cinema owners anticipated the success of Avatar in 3-D. The pipeline of 3-D movies encouraged more exhibitors to buy digital projectors to meet competition. However, 3-D only caused the conversion of a few screens per complex. To encourage cinema owners to convert all screens to digital, studios signed contracts around the world to pay Virtual Print Fees, or VPFs. VPFs are a form of subsidy for the conversion from film projectors to digital.

DCI is a joint-venture of the 6 major motion pictures studios in the US. The DCI Digital Cinema System Specification is the assurance to banks that this equipment has sustaining value in the marketplace. The importance of this cannot be understated, as without the DCI Specification, it would not have been possible to get the financial community to provide the billions of dollars of capital needed to drive the conversion of cinemas.

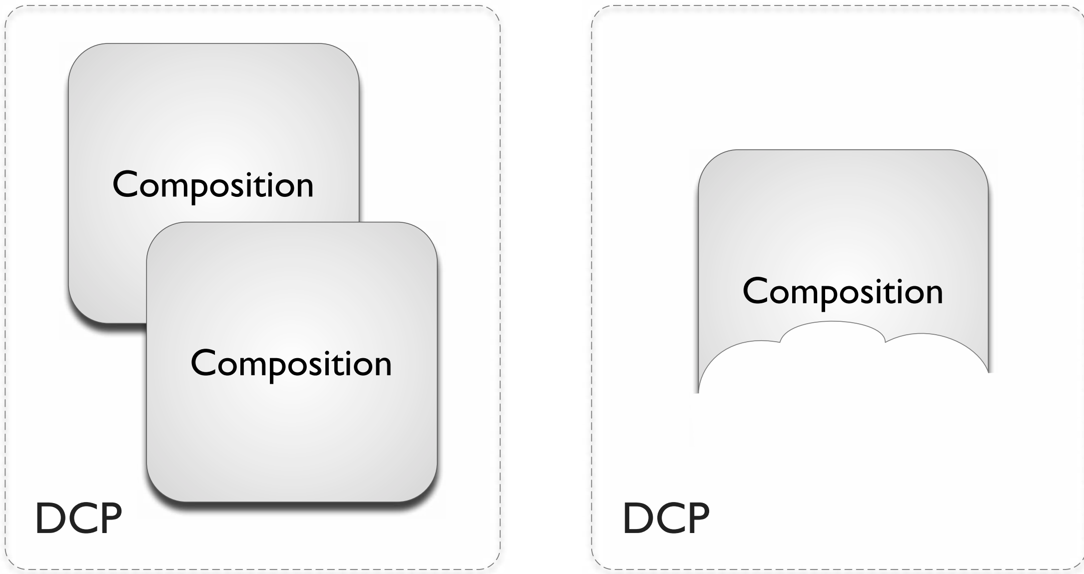
For this and other reasons, the DCI Specification will not change in nature beyond fixes and improvements. It is the 35mm of digital cinema. 3-D, high frame rates, and 3-D sound are extensions to the DCI Specification, not a change of the DCI Specification.

Composition



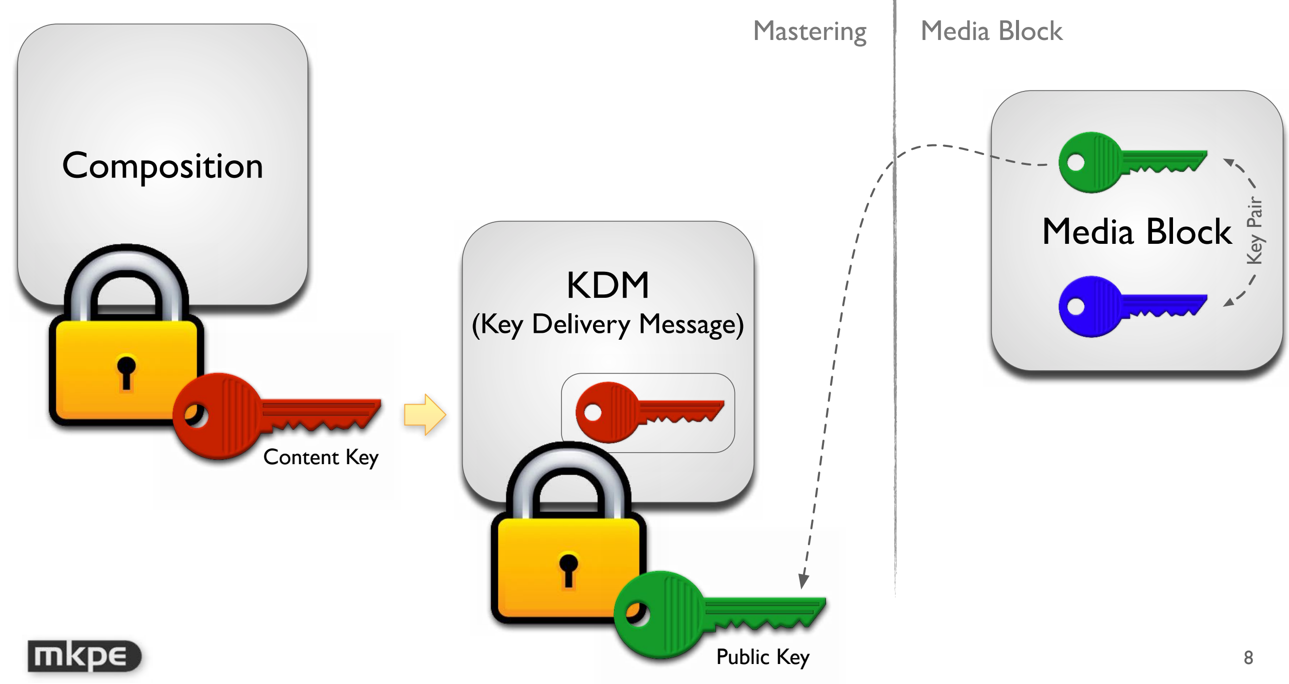
I'll now talk about the technology behind digital cinema. A digital movie is called a Composition. The Composition consists of many files. Each file contains only one essence type, which means that picture is stored in one file, and sound in another. Essence files are wrapped in MXF. Note that digital cinema does not interleave essence. Files are organized temporally in blocks of time. We call these digital reels. While film reels strive to be of a similar length of time, digital reels can be of any length. There is no restriction on the number of digital reels in a Composition. But if encrypted, each encrypted file in each reel requires a separate encryption key, and there is a limit of 256 security encryption keys that can be used in a Composition. The Composition Playlist, or CPL, is an XML file that instructs the playback system the order in which to decrypt and play the files.

DCP: Digital Cinema Package



Movies are stored as Compositions, but we talk about sending a “DCP” to the cinema. DCP stands for Digital Cinema Package. A DCP can contain one or more Compositions, or it can contain a partial Composition.

Security Key Management

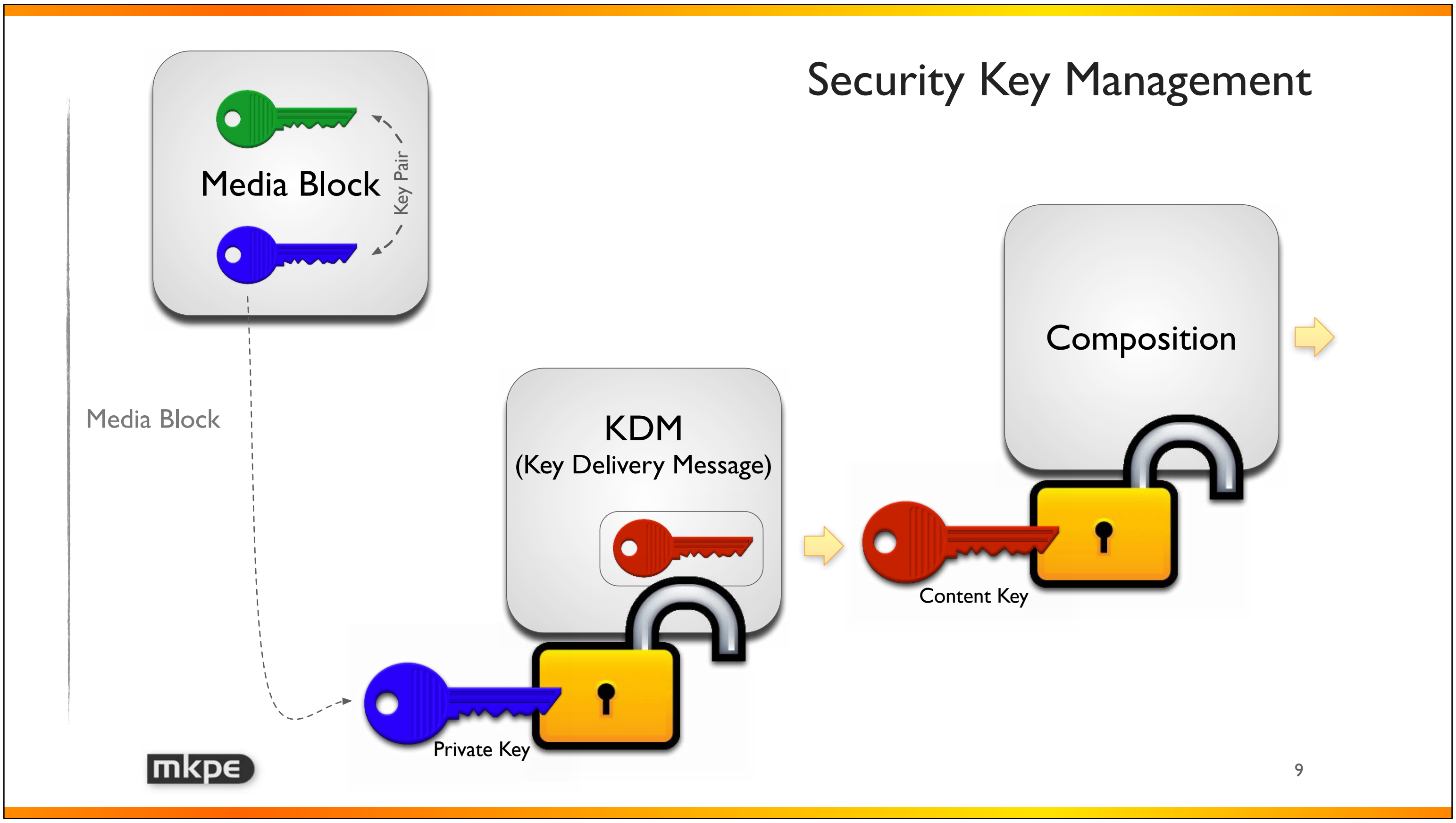


Film has no parallel to digital encryption. There are some important concepts to digital cinema encryption that I'll explain.

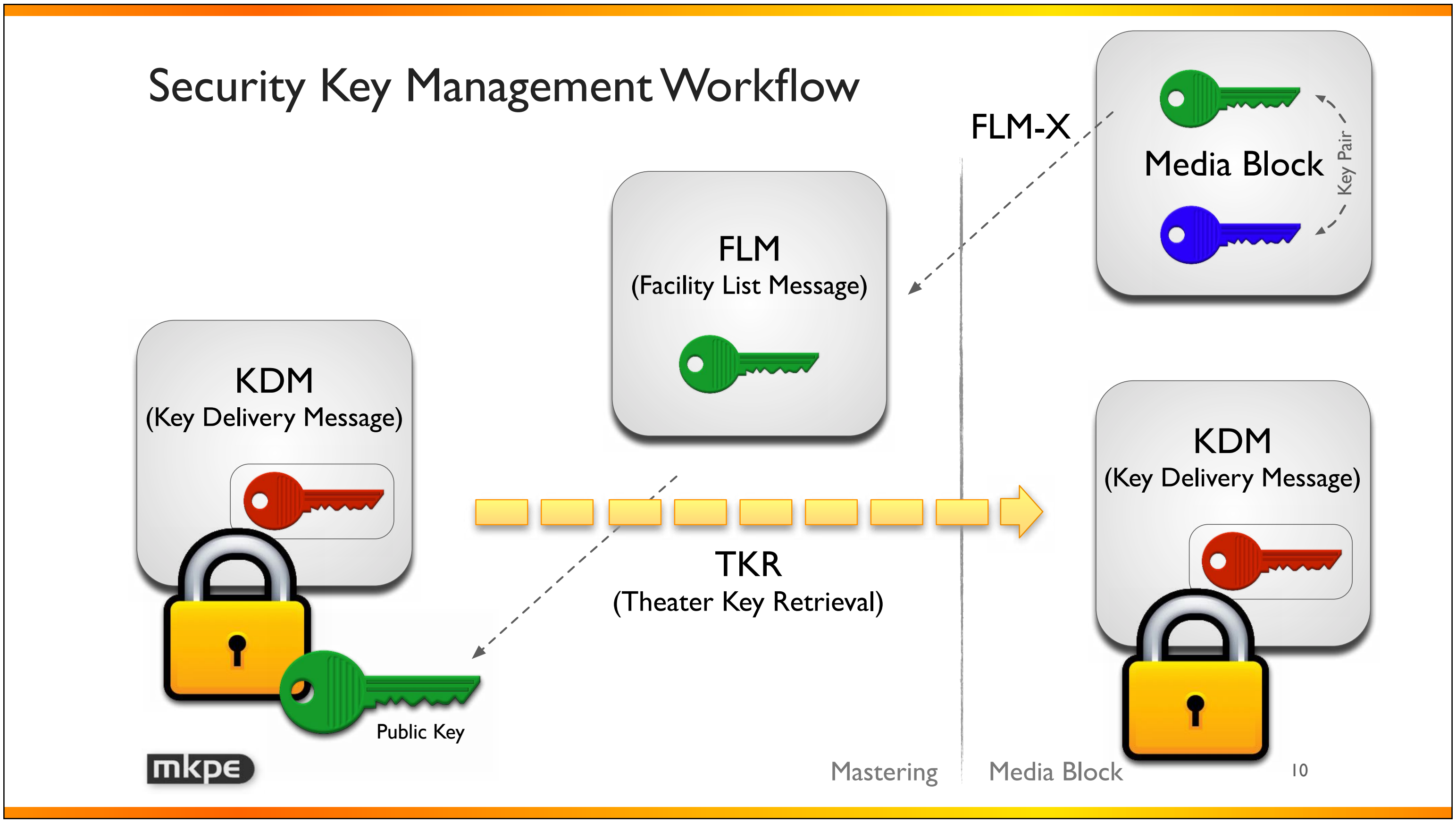
First, files in the Composition are encrypted, or "locked," with a "symmetrical" key, which I refer to here as a "Content Key" (red key). Symmetrical means that the same key that is used to encrypt a file can also be used to decrypt the file. When a Composition is widely distributed in a region, the same encrypted set of Composition files is sent everywhere.

To protect the Content Key, it is encrypted, or "locked," in separate file called a Key Delivery Message, or KDM. The KDM is a small file, and can be emailed. Each KDM is uniquely created to play in only one digital cinema Media Block. (The Media Block decrypts, decompresses, and plays the Composition.)

The "Public Key" (green key) used to encrypt the KDM is received from the Media Block that will decrypt it. It is an asymmetrical key. As the name implies, it can be exposed to the public without compromising the encryption. Only the "Private Key" (blue key) of the Media Block can decrypt the KDM. Private Keys are encoded in secure silicon, and cannot be seen by human eyes.

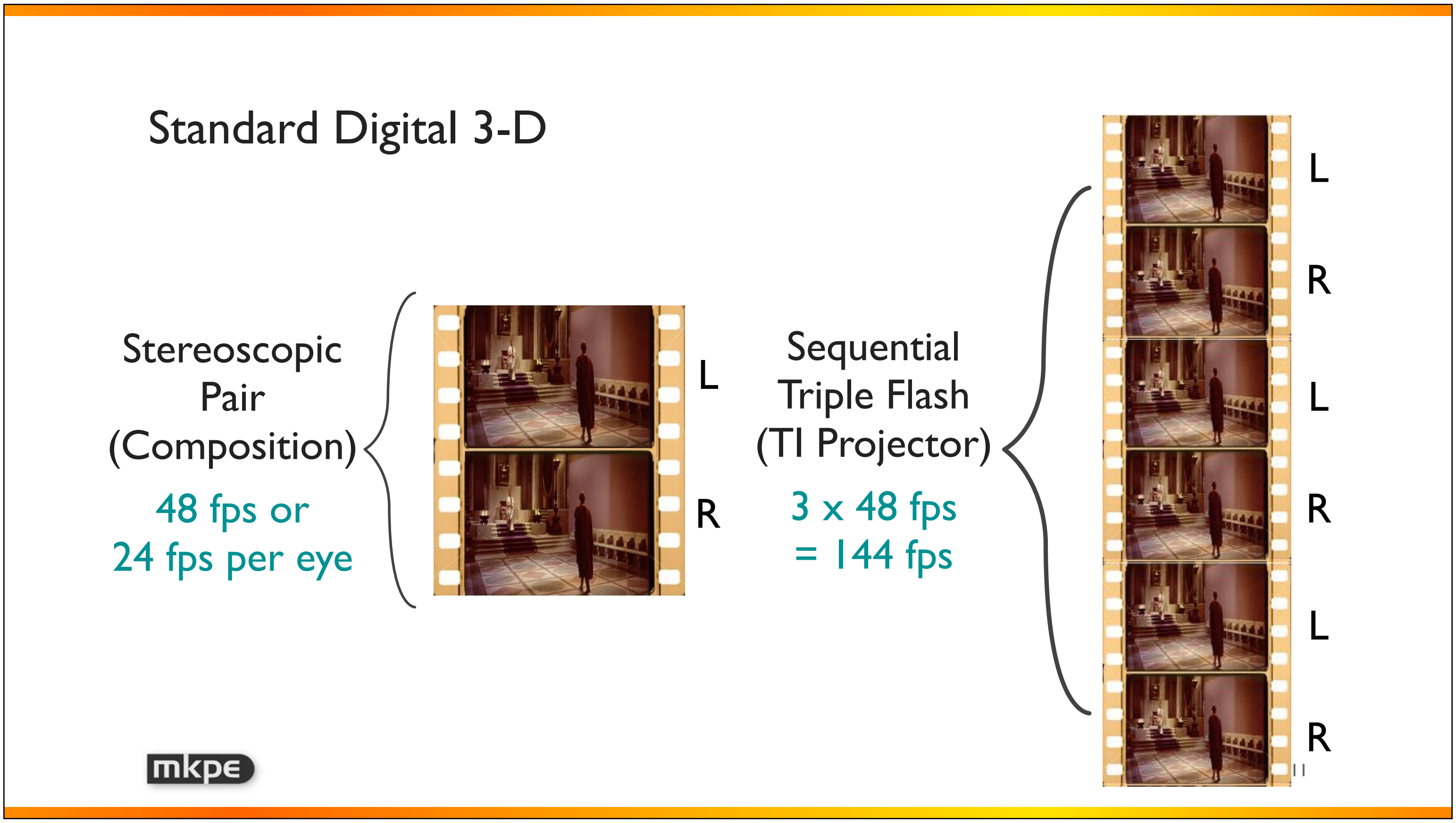


When the KDM is delivered to the Media Block, the Private Key (blue key) decrypts it, and exposes the Content Key (red key). The Content Key can then be used to decrypt the Composition. These tasks are all performed in secure silicon. A major portion of the DCI specification addresses how these secure processes are to be handled.



As in any work environment, we have workflow issues in the exhibition of digital movies. Media blocks move around or can be replaced on a moments notice. It takes a lot of care to make sure that the right KDMs are present in the cinema so that the movie plays. To carry the Public Key (green key) from the cinema to the KDM maker requires a Facility List Message, or FLM. A communication method called FLM-X is used to collect the FLM.

Once the KDM is created, it needs to be sent to the right location. To accomplish this, a method has been devised called Theatre Key Retrieval (TKR) to allow the Media Block to pull the correct KDM from a data center.



The box office maker for cinema today is 3-D. 3-D picture is stored in a single file as alternating Left and Right images. In standard 3-D, the total frame rate used is 48 fps, or 24 fps per eye. Projectors that employ sequential projection will "Triple Flash" the stereoscopic images at a total rate of 144 fps for a smoother effect.

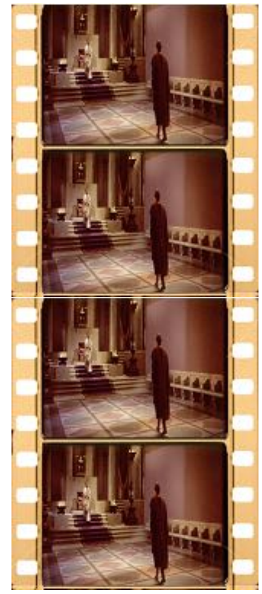
High Frame Rate Digital 3-D *(Hobbit)*

Stereoscopic
Pair
(Composition)

96 fps or
48 fps per eye

Sequential
Double Flash
(TI Projector)

2 x 96 fps
= 192 fps



In the High Frame Rate 3-D that will be used for “Hobbit,” the total frame rate used is 96 fps, or 48 fps per eye. Projectors that employ sequential projection will “Double Flash” (NOT Triple Flash) the stereoscopic images at a total rate of 192 fps.

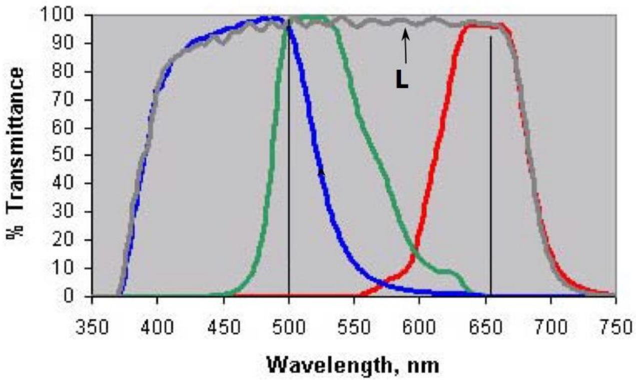
If a High Frame Rate of 60 fps per eye is used, the total frame rate is 120 fps, and no sequential flashing is used in the projector.

SMPTE Higher Frame Rate Study Group

- Document HFR capability of current equipment
- Study the JPEG2000 bit rates needed for HFR pictures
- Co-chaired by Michael Karagosian (me), Kommer Kleijn SBC, and David Stump ASC

The Society of Motion Pictures and Television Engineers has formed a Study Group to explore certain issues with higher frame rates. I co-chair the Study Group, along with cinematographers Kommer Kleijn of Imago, and Dave Stump of ASC.

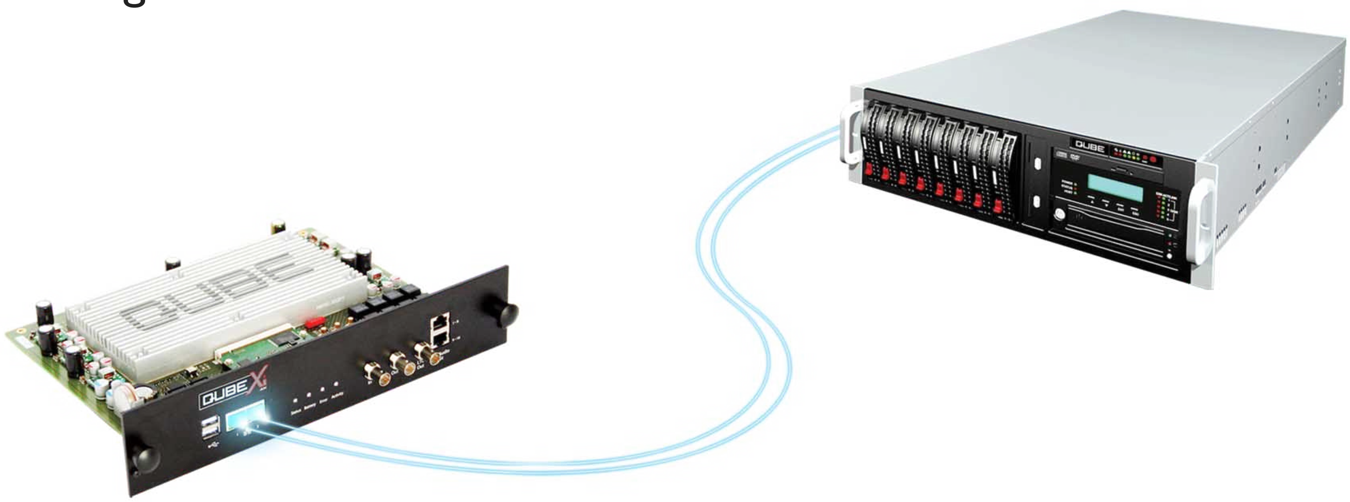
3-D Luminance



- There are no standards for 3-D Luminance
- Target 3-D luminance is 4 ft-L through the glasses
- Multiple projectors are usually required to achieve 6 ft-L or greater

While the standard luminance level for 2-D digital cinema is 14 ft-L, there are no standards for 3-D luminance.

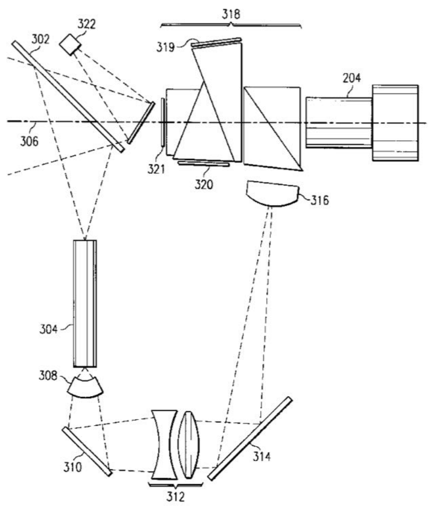
Integrated Media Blocks

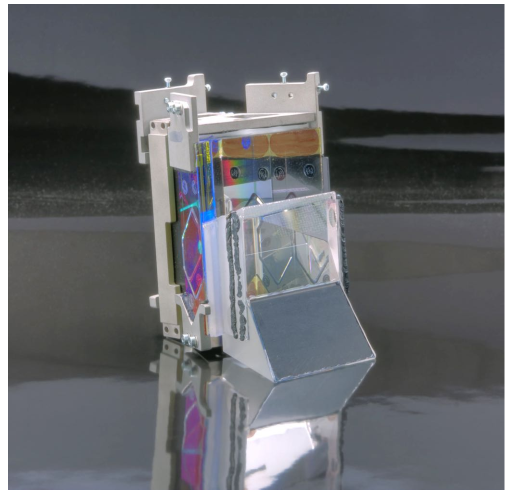


In the cinema, all pictures above 48fps 2-D will require an "Integrated Media Block," or IMB. The IMB may require an outboard server for storage, or the server may be integral to the IMB.

Some projector companies are now developing their own IMBs in an effort to bring down the cost of the projector.

Lower Cost Projectors



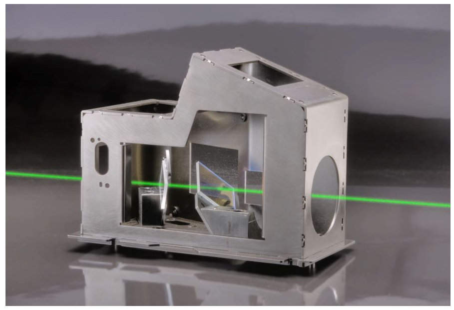


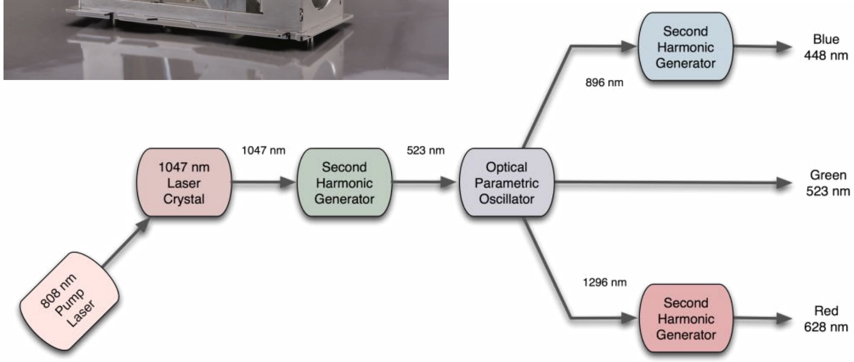
Low cost projectors require low cost optics. Texas Instruments recently announced the availability later this year of a new, smaller .7" DLP 2K imaging array. While the chip will presumably cost less than the .98" or 1.2" versions, the bigger cost savings will be in the smaller optics needed in the projector. Limiting the projector to lower light power will also reduce the cost of the glass used.

Combined with an Integrated Media Block, a complete projection solution could be offered that is DCI Compliant and less costly for smaller cinemas than current products on the market. Such products could be on the market within a year.

Laser Illumination

- Economics
- Regulatory Issues
- Speckle
- Metamerism





There’s a lot of talk in the industry today about laser illumination. Laser illumination in projectors does not mean that lasers will be pointed at the screen. Instead, laser light is homogenized into a beam capable of lighting the imaging device.

The visual advantages of laser illumination is the absence of infrared light, allowing more light to be used without burning the optics. The economic advantage of laser illumination is the high electrical efficiency possible. Laser light sources are expected to have 100x the lifetime of xenon lamps, at some 25-50,000 hours, while consuming 30% - 50% less power.

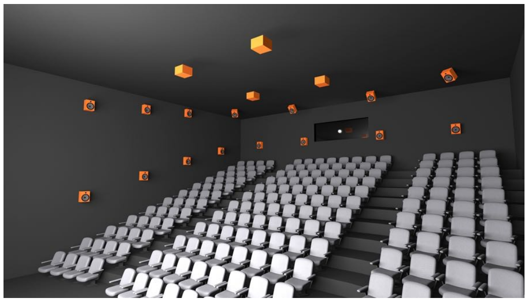
To be effective, laser illuminators must pay for themselves within 5 years. Regulatory Issues must also be overcome, as most countries ban the use of high power laser technology in any product that emits into an auditorium.
Laser illumination has its technical issues as well. Speckle, an artifact produced by wavefront additions and cancellations in reflected coherent light, must be minimized to produce an acceptable image.

Metamerism is also a problem, caused by the narrow frequency range of each primary. Without widening the spectral characteristics of the primaries, not everyone will see the same colors when viewing laser illuminated projection.

3-D Sound

immsound

DOLBY ATMOS
HEAR THE WHOLE PICTURE



IOSONO
the future of spatial audio

ILLUSONIC

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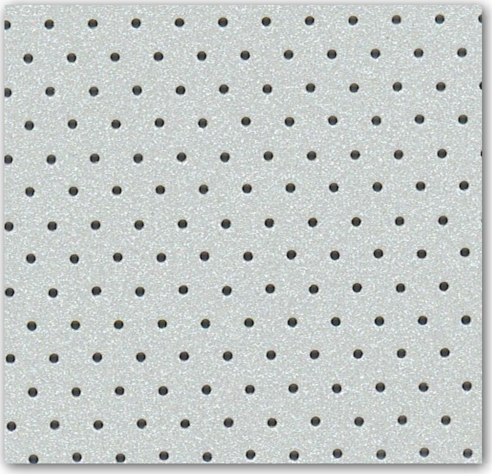
For the past 12 years, the industry focused on achieving digital projection with a quality level that matched that of film. Now it's audio's turn to shine. Audio in the cinema is undergoing a renaissance, with no less than 5 companies having announced new sound formats that surround the audience with sound in a hemispherical manner. Two weeks ago, Dolby announced its entry into this area, called Dolby Atmos. Competing formats are offered by Imm Sound, Iosono, Barco's Auro 11.1, and Illusonic.

Next Generation Screens?



Are those perforations really necessary?

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The one area that remains untouched is that of the screen. Perforated screens lose light and have been known to cause moire patterns in some digital cinemas, by beating with the pixel pattern of the projector. The challenge is to make a screen that is acoustically transparent, but highly reflective to light.

Digital Cinema 2.0

- Higher Frame Rates
- Integrated Media Blocks & Servers
- 3-D Sound
- Higher Luminance

If one adds up all of the innovations I just talked about, we have a new advanced cinema, Digital Cinema 2.0.

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