



The future of cinema is
smooth, crisp and amazing

The future of cinema is all about high frame rates

With the advent of digital cinema, the movie industry is finally able to affordably shift away from production and playback techniques that date back almost a century, to new High Frame Rate (HFR) and 3D HFR technology that delivers more realistic viewing experiences.

HFR movies record and play visuals at twice or more the rate of that seen in today's cinemas, meaning less flicker, motion blur and stuttered movement. The improvements to 3D movies will be particularly dramatic, creating ultra-realistic movie-going experiences, and resolving some of the issues that have been problematic for the medium.

Some of the biggest movies on the horizon – a pair of Lord of the Rings prequels and Avatar's sequels – will use 3D HFR. Avatar director James Cameron is working with Christie in leading the global R&D effort to make the industry ready for this big shift – from the film set and all the way to the local movieplex.

HFR provides directors and cinematographers with a new medium for storytelling. They will enjoy enhanced creative freedom on set with support for a wider range of camera moves. HFRs will also have profound effects on the ability to capture and display sporting events, theater, and dance.

Christie is leading the industry in developing HFR technology, and is in the process of rolling out a transition plan for exhibitors.

The drive is on to make theater operators fully ready for the HFR-driven movie experiences that are coming in late 2012. For the cinema business, adopting HFRs will mean more satisfied customers, more filled seats, and direct contributions to bottom lines. It will also improve the overall product, and expand business opportunities for alternative content already coming at High Frame Rates.

In this brief, we'll walk you through the background on frame rates and their technical basics, explain some of the issues and challenges faced by the industry, outline where things are going and, finally, explain how easy it is for Christie customers to become part of the HFR evolution.

Background

A hand-cranked history

Frame rate refers to the number of images displayed by a projector within one second. In the early days of cinema, silent movies were shot by hand-cranked cameras at frame rates of anywhere from 14 to 24 frames per second (FPS), and played back at roughly the same rate.

When "The Talkies" were born, effectively ending the silent movie era, a steady playback speed was needed to keep the audio in these new sound movies synchronized with the visuals. Using more frames meant more costs for film and processing, and studio bosses found 24 frames per second was the cheapest, minimally acceptable frame rate they could use for showing these new "talking" movies with relatively smooth motion.

That 24 FPS standard is still around today, almost a century later. Since the late 1920s, projectors have been using shutter systems that show the same frame two or three times to boost the overall frame rate. That reduces much of the flicker audiences would otherwise see, but it's still not enough to keep up with the fast motion of action movies and sweeping, panning shots.

The jerkiness that's just become a part of conventional filmmaking is visually accentuated in 3D, because watching eyes are working particularly hard to focus on moving objects.

How frame rates work in 3D digital cinema

For single projector systems, alternating images are shown to the left and right eyes of people in the audience, who are wearing some type of 3D eyewear – either polarized, shuttered or spectral division glasses.

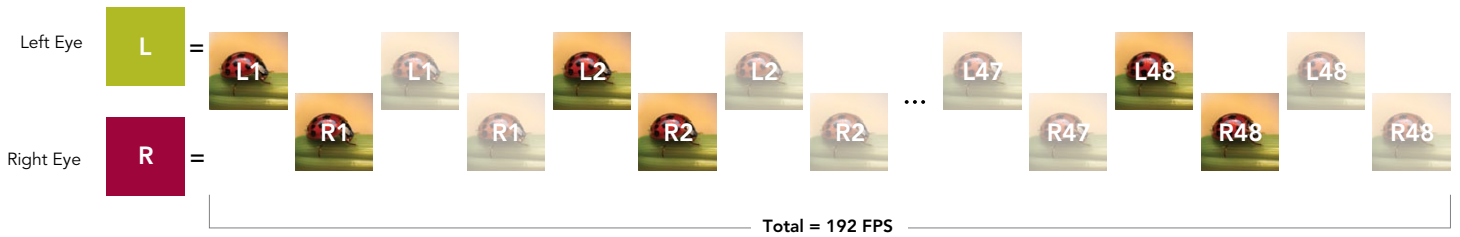
For the 3D movies that have already been running in theaters, the current generation of DLP® Cinema™ projectors are showing the movies at 24 FPS, but actually flashing each frame image three times. Called triple-flashing, it means viewers are actually seeing 144 frames per second. The flashing is done to eliminate any perception (and therefore the distraction) of the sequential progression of frames.

While it's still too soon to know if multiple image flashing will be as important with HFR content, the technology to accomplish this will be included in every HFR-capable Christie projector. Shot at high frame rates, new 3D movies would be double-flashed by projectors to remove any hint of flickering. Fans watching a film produced at 48 FPS would see the same frame flashed twice per second, resulting in 96 FPS seen by each eye and 192 FPS overall.



▲ Triple flashing

In order to project standard frame rate 3D with minimal viewer discomfort, the projector “flashes” a frame for each eye, three times as fast. This tripling of the frame rate (from 24 FPS, per eye to a total of 144 FPS per eye) provides a smoother look and gives standard frame rate content the best motion rendition possible.



▲ Double flashing

With feature film content shot and produced at high frame rates, high frame rate-capable projectors will “double flash” or duplicate each frame. This increases the overall frame count to 192 FPS or 240 FPS without increasing the number of repeated frames. Doing so, removes any hint of flickering, strobing and judder and creates a more compelling and engaging movie-going experience.

Films produced at 60 FPS, and then double-flashed, would result in movie-goers seeing a 3D film at an ultra-smooth 240 FPS.

The television industry is already using much higher frame rates of between 50 and 60 frames per second, with some of those standards dating back to the 1940s. Consumers with HD services and HDTVs are now accustomed to watching content that delivers extremely smooth motion and crisp, vivid detail. Sports and live events are now routinely captured and broadcast in high frame rate HD, elevating consumer assumptions on how things should look.

24 FPS has its fans and foes

The decades-old 24 FPS standard is beloved by film purists, who say it delivers a depth, grain and tone that is special to the movies, and not possible with digital video. They embrace 24 FPS just like audiophiles embrace the tone and warmth of 2" magnetic recording tape and old 33 RPM vinyl records. Digital removes the flaws, they concede, but at the expense of character.

The “Soap Opera Effect” has been derisively used to describe film purist perceptions of the cool, sterile visuals they say is brought on by digital.

But the success of Hollywood, Bollywood and big-budget filmmakers around the world has little to do with moody art-house films. The biggest blockbusters are usually about immersive experiences and escapism – big, vibrant, high-action motion pictures.

Using conventional frame rates, the flaws of 24 FPS are amplified and the overall viewing experience is compromised.

Films shot and delivered in 24 FPS have persistent problems with flickering and stuttering visuals – called strobing and judder by the technical side of the movie business. At just 24 FPS, fast panning and sweeping camera movements that are a critical part of any blockbuster are severely limited by the visual artifacts that would result. Filmmakers go to great lengths to overcome these effects, even adding blur effects to make motions appear smoother.

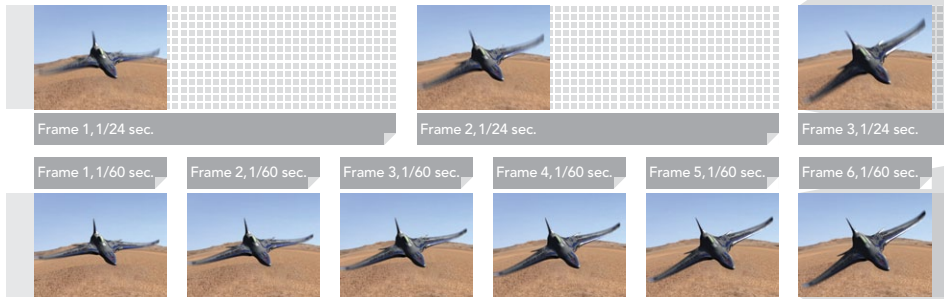
Worse still, with the relatively long exposure time of a 180-degree camera shutter at 24 FPS, moving objects tend to take on a “motion-blurred” appearance as their position is captured at multiple positions within a frame.

When a film is shot and shown in 3D, the flaws of 24 FPS are even more obvious because of the technical challenges and the sheer volume of visual data being processed and pushed through projectors to screens. HFRs, it’s argued, will minimize or stop the motion blur, judder, and strobing audiences now see.

As for film style, famed directors like Avatar’s James Cameron argue there’s much more to film style than just frame rates. It’s about how scenes are lit and the angles of shutters.

24 frames per second

Films shot and delivered at 24 fps have persistent problems with flickering and stuttering due to too few frames for fast moving objects to smoothly transition across a large screen. Additionally, each frame is suspended for a longer duration, adding to the overall stuttering effect.

**60 frames per second**

Increasing the frame rate not only provides more frames to better represent fast moving objects, it also provides increased image detail as the camera shutter is open for 2.5x less time per frame. When projected with Christie Previsto™ high frame rate technology, your audiences will be amazed.

**HFR at the movies****High frame rates demanded**

Filmmakers are now demanding the motion picture industry adopt HFR standards that reduce the motion blur, judder and strobing that's now common, and instead deliver enhanced/immersive 2D and 3D experiences for movie-goers. HFRs will give them the tools and delivery platform they need to fully realize creative ideas.

Filmmakers also say the stunning realism that comes with HFRs – through smooth action shots and pans, and crisp images – will bring people into movie-houses for experiences that cannot be matched by TV, gaming or other diversions.

For exhibitors, HFRs introduces a new level of viewing experience and with it, the notion of up-charges to pay for that premium experience. The upgraded seating and enhanced amenities introduced at many cinemas can potentially be supplemented by selling premium visual experiences in HFR-equipped theaters.

HFR already in production

The directors behind some of Hollywood's biggest box office successes see HFRs not as the future, but the present.

Lord of the Rings trilogy director Peter Jackson is now filming a two-part prequel, The Hobbit, at 48 FPS and in 3D. The first of two parts is targeted for release in Dec. 2012.

Jackson has said even the old 24 FPS film purists in his crew have been won over by the more comfortable, lifelike viewing experience brought on by HFR shooting. He likens the advent of HFR to the moment when CDs came on the market, signaling the inevitable end for vinyl records.

Directing colleague James Cameron, an outspoken HFR proponent, has said the 3D sequels to Avatar, the top grossing movie in history, will be shot at HFRs. Film technology buffs are speculating Avatar 2 and 3 will be shot, beginning in 2012 or 2013, at 60 FPS.

Other HFR film projects will undoubtedly follow, and outside of motion pictures, exhibitors have an emerging new revenue opportunity in alternative content screenings, such as performances by the New York City Opera. The return from such events, as a percentage of overall business, is small but still significant for exhibitors.

However, current technology limitations may also affect that business. While the clarity, color, and image quality people see at the movie theater exceeds that of their home televisions, the sensation of fast-action motion simply cannot be replicated on big screens without HFR technology.

Digital cinema's evolving business needs

The major motion picture studios, wanting the cost savings and clarity that comes with

interoperability, formed a joint venture almost a decade ago and started developing Digital Cinema Initiatives (or DCI) standards for the digital movie business – covering the chain from the production houses all the way through to manufacturers and exhibitors.

Those DCI standards addressed things like resolutions and encoding bit rates, as well as frame rates. Both 24 and 48 FPS are now DCI standards, as is 48 FPS (24 FPS/eye) for 3D.

Standards are good, but some challenges remain. The DCI standard for 3D has frustrated directors who see flaws in the finished product brought on by the traditional frame rates. The two biggest 3D HFR movies now in different stages of production, The Hobbit and Avatar 2, will be shot at higher and likely differing frame rates.

There's also limited experience and few standards, as yet, for the actual production of movies in HFR, or for showing them. Christie® is working with several film research groups to examine the use of HFRs in cinema to assist in the establishment of best practices for the industry.

With the technology still very new, and evolving, exhibitors are confused by what they'll need to do and what it might cost. While they may generally understand HFR does not represent a wholesale technology shift like the conversion from analog to digital, they also assume there are budget implications.

“If watching a 3D movie is like looking through a window, then [with this] we’ve taken the glass out of the window and we’re staring at reality.”

Avatar director James Cameron on high frame rate movies

How HFR fits in today

Digital cinema projection systems have three primary hardware components:

- 1 A storage device that holds the content (such as feature films, trailers, alternative content and related media)
- 2 A media block that decrypts, decodes, and formats content during playback
- 3 The digital cinema projector that’s driving images to the screen

Historically, the storage and media block have been physically distinct from the projector in a device commonly referred to as a server. In between the server and projector is a dual HD-SDI cable link that moves the video data. That connection is actually a bottleneck, brought on by the sheer volume of uncompressed video data that needs to be moved from the server to the projector. Even with today’s 3D 24 FPS/eye content, half of the color information must be discarded to allow the video data to move across this interface. Some observers suggest the visual impact is minimal, but it’s nonetheless a quality compromise.

With HFR cinema content, there is so much data, there’s absolutely no way to move the image content across this cable interface.

The best way to deal with the bottleneck is to remove it, through an Integrated Media Block (IMB) architecture that puts the media

block physically inside the projector. HFR content would pass directly to the projector, completely uncompromised and using all the available color information for the movie.

When cinemas show alternative 3D content using existing digital cinema projection technology, such as live sporting events and concerts, the projectors are set for 24 FPS/eye cinema and can’t currently support the high frames at HD resolutions people now see on HDTVs in their living rooms.

Moving forward with Christie

Christie has a simple two-step solution that let its exhibitors take full advantage of the HFR evolution that’s now emerging in digital cinema.

- 1 First, we’ve developed software that makes any existing or new Series 2 Christie cinema projector ready for HFR alternative content, like live sporting events and concerts. The Christie Solaria™ 2.2 software is a firmware upgrade that requires zero down-time to make the changes. Your local technical partner can handle the upgrade, or theater operators can download this new software to a USB drive and follow a few simple steps to make the changes themselves.

That firmware upgrade enables the projector to accept video content at higher frame rates than traditional cinema content, and passes it through the video pipeline of the projector, while maintaining or enhancing the visuals

that hit the big screen. It will handle both cinema and alternative content at 48 and 60 FPS/eye.

The software will also be a new tool in the highly complex and highly collaborative post-production process for 2D and 3D HFR films. It will let everyone in the content creation pipeline emulate the same DCI big-screen cinema environment, without having to deal with formal digital cinema packaging and security procedures.

- 2 Exhibitors must choose an HFR capable Integrated Media Block (IMB). In early 2012, months ahead of the first major 3D HFR theatrical releases, Christie will have an HFR (IMB) that fits into any of the Solaria Series 2 projectors already on the market. This IMB will remove the need for the HD-SDI cable link and make the bandwidth bottleneck issue disappear. It will also increase data security by doing the decrypting work inside the projector, away from any external connector that could invite tampering. It’s designed to work seamlessly with the projector’s HFR software.

The IMB module is an electronics board that fits in a spare slot already designed into Christie Solaria Series 2 projectors. A technical partner or theater operator can easily pop open a blank faceplate and snap the module into place, again with minimal down time.

Directors' choice:

James Cameron works with Christie on 3D HFR's development

Christie has been leading efforts to take 3D HFR digital cinema from concept into the mass market, working with industry technical partners and the technology's most celebrated proponent, Avatar director James Cameron.

Christie and Cameron's Lightstorm Entertainment are in a long-term partnership to research, test and technically support advances in 3D HFR. In March, Cameron worked with Christie and other technical partners to demonstrate a groundbreaking "proof of concept" screening of footage he shot at different frame rates, at CinemaCon 2011.

Scenes of a medieval dinner feast and a sword fight were shown back-to-back in 3D, at 24, 48 and 60 FPS. Multiple versions were shown of the same takes to demonstrate the impact of HFR on some of the biggest visual challenges facing cinematographers.

The setup used two projectors and a lot of special configurations, but it effectively made the point about 3D HFR's visual differences and impact. Strobing problems were gone, action shots were smooth and there was much better image clarity during panning.

One technical journalist invited to the demo later described the jump from 24 to 48 frames as astounding.

A few months later, Christie presented the world's first mass-audience screening of 3D HFR, this time using a single production model digital cinema projector. The demo at the IBC trade show in Amsterdam used a Christie Solaria Series CP2230 projector, along with other currently available components, to project footage of the famed Cavalia equestrian troupe in action, in 3D, upscaled to full HD at 60 FPS. Immediately following Christie's demo, Cameron used Christie equipment in a presentation to the IBC crowd about the business of 3D, and to show new 3D content for Titanic and Cirque du Soleil.



▲ Kathryn Cress, George Scheckel and Craig Sholder from Christie, with James Cameron, at CinemaCon 2011.

Photo courtesy of Ryan Miller/Capture Imaging

The business opportunity

The continued rise of 3D

The penetration of digital cinema and 3D-projection capability has exploded in the past two years in North America and globally. In the United States, the National Association of Theater Owners (NATO), in its annual state of the industry report in Spring 2011, said of 39,000 screens in theaters, nearly 16,000 were now digital, and almost 9,000 of those were 3D-ready. Exhibitors are estimating as many as 600 more 3D-ready digital screens go live each month in the U.S.

The story is the same globally. Texas Instruments, the manufacturer behind the Digital Light Processing (DLP®) technology used in most digital cinema projectors, reported that more than 44,700 digital screens were live by the end of August 2011, two-thirds of them 3D-ready.

That rapid transition is being driven by two things. First, analog film prints are expected to be largely unavailable by the start of 2014. But it's also because 3D grosses are driving the box office for movie studios. Grosses for 3D represented 21% of total receipts in the U.S. last year. In dollars, 3D accounted for \$2.2 billion of the \$10.56 billion domestic box office in 2010 – up an astounding 91% over 2009.

Of 165 2D movies that did more than \$1M in box office receipts in 2010, nine were among the Top 20 grossing movies for the year and the rest were 3D, even though only 21 2D/3D movies were released last year.

Based on those results, more and more 3D movies are now going into production. In 2010, 25 3D movies were scheduled. In 2011, 47 were scheduled.

A fast-moving train

Digital cinema has turned into a fast-moving train, impossible to stop and largely driven by the box office performance of 3D movies. The two most anticipated movies on the release horizon are both being shot in 3D HFR. At these high frame rates, both 2D and 3D films are expected to deliver viewing experiences never seen on big screens. For movie buffs, it's a treat. For theater operators, it's an opportunity.

Beyond the simple turnstile dynamics of "must-see" movies, a new, higher standard of movie-going should support premium pricing. Managed right, hotly-anticipated 3D HFR movies should empower ticket up-charges.

The research firm Ipsos Media CT recently polled movie-goers about 3D, and concluded that consumers actually expect premium charges, and will pay them, to have what at that point is considered a premium movie experience.

More and more filmmakers are expected to announce plans to shoot their big budget movies at the new high frame rates, and that will likely accelerate as the discussion moves from technical circles to the people in the seats – as the movie-going public sees The Hobbit in 48 FPS and 3D.

Conclusions

The move to HFR really is the future of movie-going, for everyone from the visionary directors to the people making entertainment decisions on a Friday night.

HFR will raise visuals to a quality never seen on the biggest screens, and likely muzzle many of the naysayers who highlight the performance flaws – like strobing and judder – in current 3D cinema, and generally dismiss 3D cinema as a passing fancy.

For big-budget filmmakers, HFR ends a lot of production compromises and frustrations, and lets them fully realize visions.

For exhibitors, the HFR experience should reinforce and amplify the need to see new movies now, on the big screen. For the most anticipated releases, premium pricing for an enhanced experience is a real, justifiable proposition for audiences.

Christie is committed to leading the development and support for advanced cinema technologies. Our steady R&D and deep ties into the motion picture community have made Christie the "director's choice" for the collaborative advancement of HFR display technology. We've recognized the opportunity, but also the technology challenges presented by this massive jump in the visual data being pushed to screens.

With the backing of Christie's knowledge, its partnerships and long history of delivering top-quality technology, exhibitors know they don't need to become HFR experts to fully understand and capitalize on it. We've done, and are continuing to do, the work needed to take care of that, all through the movie eco-system.

HFR is a big moment for the movie business, but we don't think it needs to be a lot of work or cost for our customers. We future-proofed the investment in our technology, and we've developed a clear roadmap and easy upgrade path that keeps our exhibitor customers one step ahead of where the motion picture industry is going.

For more information on Christie Solaria Series software upgrades, the Christie IMB, Christie's Virtual Print Fee (VPF) program for financing the switch from film to 2D and 3D HFR-enabled projectors and other aspects of Christie's HFR solutions, please contact your local Christie representative.

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