3DTV Overview – IEEE Denver Signal Processing Society
April 7, 2010

ONE

Chris Lennon
CTO Group

ONE Company. ONE Direction. The Future.


THE TIMES-PICAYUNE
© 2 0 1 0
MOVIES...TV... MAGAZINES... WHERE WILL IT SHOW UP NEXT?
3-D CRAZE

Overview

What We'll Cover:

- What is 3D?
- 3D Cinema – setting the stage for 3DTV
- Rapid rollout
- Displays
- Cameras
- Distribution Formats
  - Frame-compatible
  - 2D + Difference
- Things to Ponder
- 3DTV Standards Activities
- Harris and 3DTV

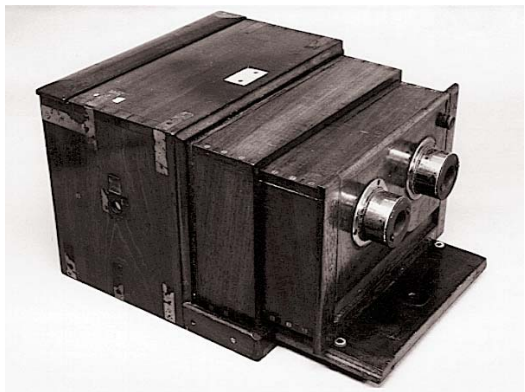
What is 3D?

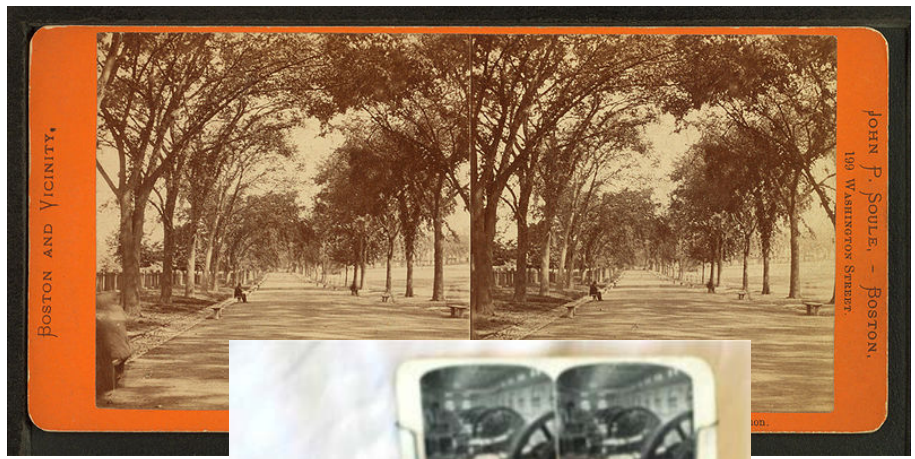
A 3-D ("three-dimensional") photograph, movie or TV a picture that provides the *illusion* of depth perception.

This technique is often referred to as stereoscopic, given two different views are used, just like our left and right eyes do.

What is 3D Hype about?

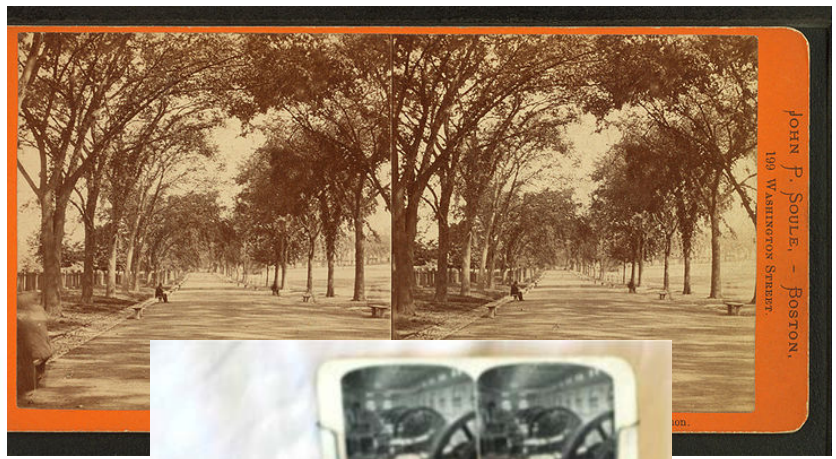
3-D certainly isn't new. Stereo cameras have been around for over a century





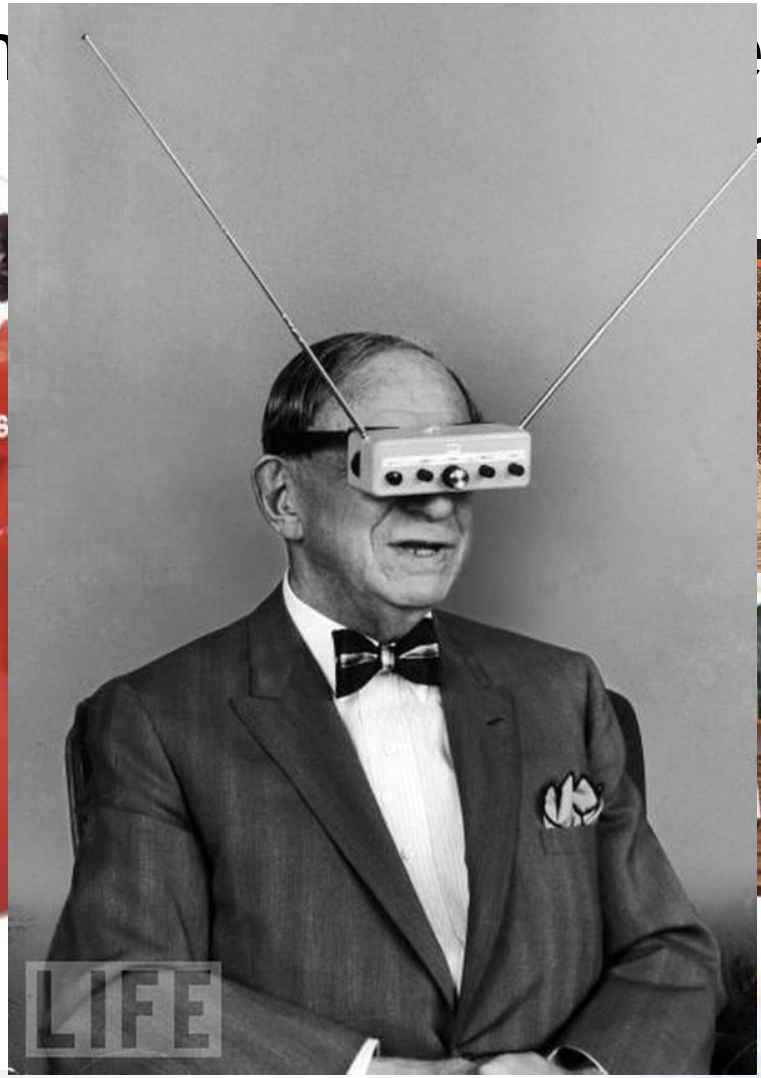
What is 3D Hype about?

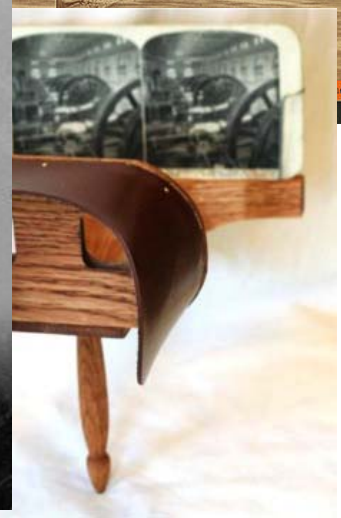
3-D certainly isn't new. Stereo
en around for



What is 3D Hype about?

3-D certain ereo
nd for





3D Games & Web 3D

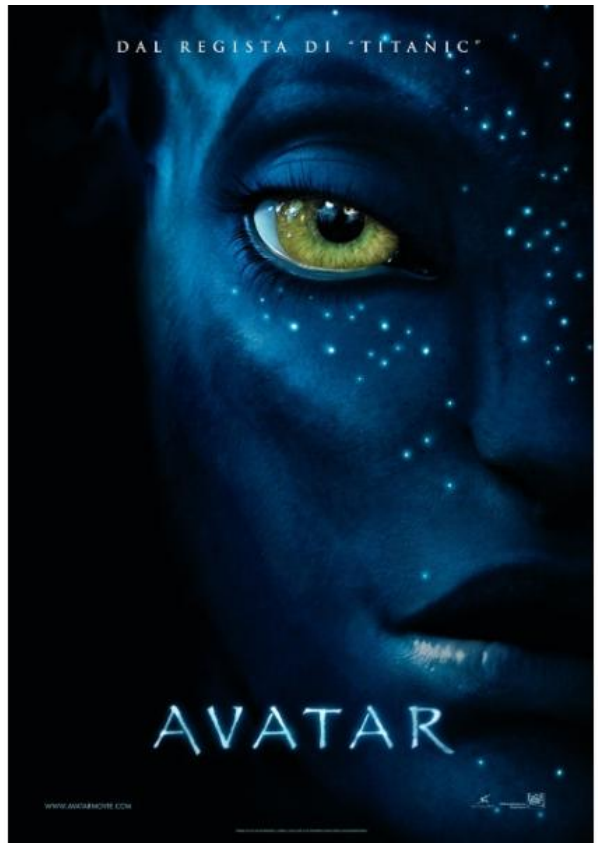
- Games & PCs
  - 425 3D games released
  - Major monitor manufacturers offer 3D
  - 1M 3D PCs by mid 2011
  - Glasses which allow you to adjust convergence yourself (decrease discomfort)

- Web
  - Adobe Flash 3D
  - YouTube3D
  - Google Earth
  - Next3D
  - Live full-res 1080p 3D streaming shown at CES
  - Some anaglyph, but heading largely toward side-by-side

3D Cinema

3D Cinema

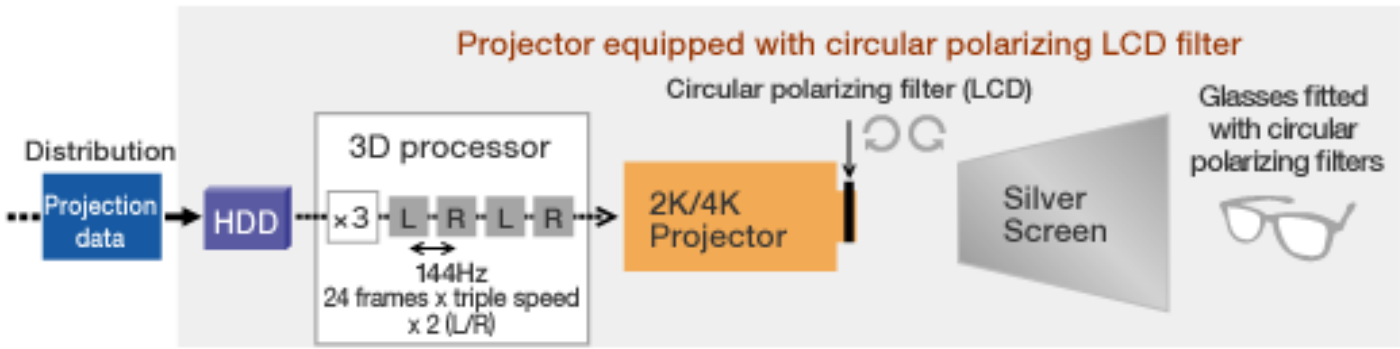
- 35 3D films in 2009, 28M viewers
- Many tout 15% incremental cost, averages 2.4x revenue
- Animated features
  - Created in 3D space anyway
  - Simply render second eye view on computer
  - All Dreamworks, almost all Disney, and many independent going 3D



- Live action
  - James Cameron showed everyone how to do it very well with Avatar
- Next genres: Horror and high profile releases

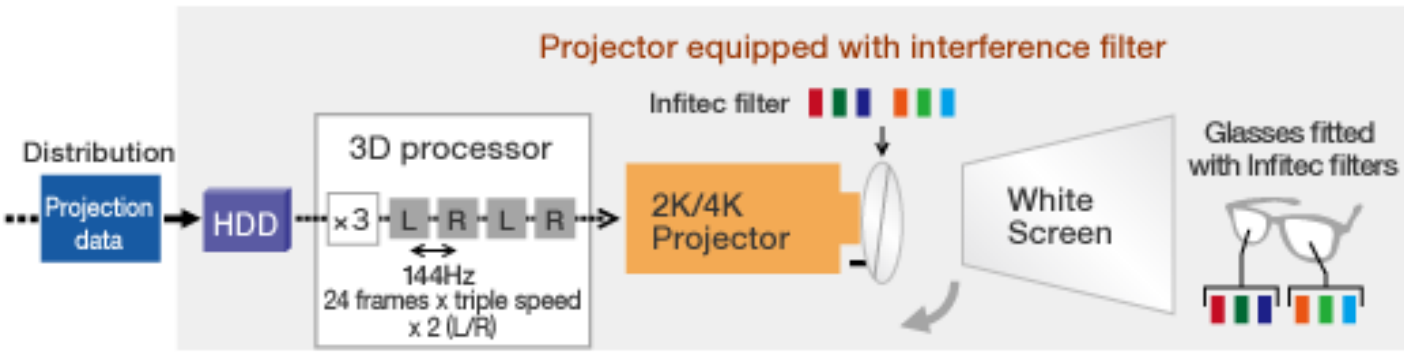
3D Cinema - RealD™

- LCD circular polarizing filter placed in front of the cinema projector lens.
- Two streams of image data, left and right, are circularly polarized - clockwise and anticlockwise - to generate pictures for the left and right eyes, respectively.
- These are alternated at high speed for projection on a silver screen, watched by an audience wearing glasses fitted with circular polarizing filters. The alternating images reflected from the screen are thus seen by left and right eyes alternately, allowing the viewer to enjoy a 3D experience.



3D Cinema – Dolby® 3D

- Each of the three primary colors - red, green and blue - is split into 2 different wavelengths, one for the left eye and one for the right eye.
- For projection, an interference filter (Infitec) is rotated at high speed, displaying RGB for left and right eyes alternately, while the viewer wears Infitec filter glasses for this "wavelength multiplex visualization system."



3D Television

- What is 3DTV?
  - More accurately, “stereoscopic television”
  - Two pictures presented to viewer (one for each eye)
  - Brain combines two views and interprets it at a 3D view

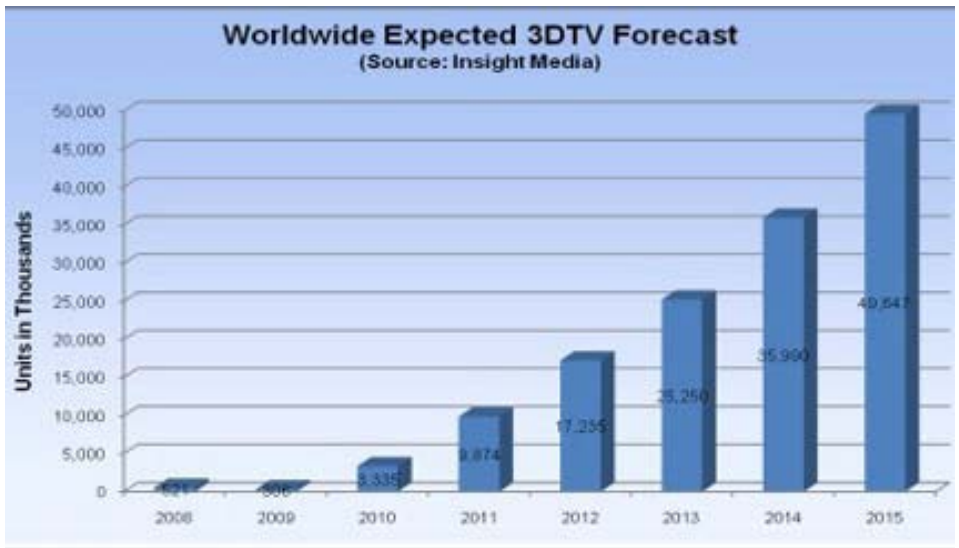
3DTV is happening now!

Why is it “for real” this time?

- Digital is the difference
- True HD quality (or close to it)
- Nausea, discomfort issues addressed
- Production “lessons learned”
- ROI is clear
- Industry needs a follow-on to HD (media, consumer, and professional equipment companies)
- Rapid embrace by consumers (25% plan to buy a 3DTV within 3 years)

3DTV is happening now!

- Quick CE Facts
  - 25% expect to buy a 3DTV within 3 years
  - 20% say they never will (2003: 33% said never for HDTV)
  - 10% of TVs 37” and up sold in 2010 will be 3D
  - By 2013, ¼ of all TVs will be 3DTVs



(Credit: Insight Media)

3DTV is happening now!

- Highlights just in the last year or so…
  - Dec 4, 2008: NFL simulcast to theaters
  - Jan 8, 2009: College football simulcast to CES
  - Feb 14, 2009: NBA All-Star Game
  - March 9, 2009: BSkyB 3D Announcement
  - April 6, 2009: BSkyB 3D Test Successful
  - April 20, 2009: Panasonic full 3D production announcement
  - Sept 2, 2009: Sony 3DTV announcement
  - Sept 10, 2009: NEP 3D truck rollout
  - Sept 11, 2009: BBC says some of 2012 Olympics could be in 3D
  - Sept 12, 2009: ESPN 3D Football game to theatres
  - Oct 1, 2009: Sony single lens 3D camera announced
  - Nov 23, 2009: Sony $10B 3D announcement
  - Dec 3, 2009: FIFA World Cup announcement
  - Dec 18, 2009: Avatar release
  - Jan 4, 2010: ESPN 3D channel announcement
  - Jan 5, 2010: 3DNet - Sony/Discovery/IMAX 3D network announcement
  - March 9, 2010:CBS Final Four announcement
  - March 15, 2010: Comcast 3D Masters announcement

3DTV Deployments

- Who's Deploying 3DTV?
  - BSkyB
    - Will work on existing STBs (Sky+HD boxes)
    - Movies, entertainment, sports
    - Focus on pubs & clubs
    - Q2/3 2010
  - DirecTV
    - 3 channels (two linear, one VOD)
      - Working with AEG/AEG Digital Media, CBS, Fox Sports/FSN, Golden Boy Promotions, HDNet, MTV, NBC Universal and Turner Broadcasting System
      - Initially single PPV channel – movies, documentaries. etc.
      - Launch in June
      - Software update on existing MPEG-4 STBs
      - 2010 MLB All-Star Game on Fox Sports
      - Exclusive sponsor: Panasonic

3DTV Deployments

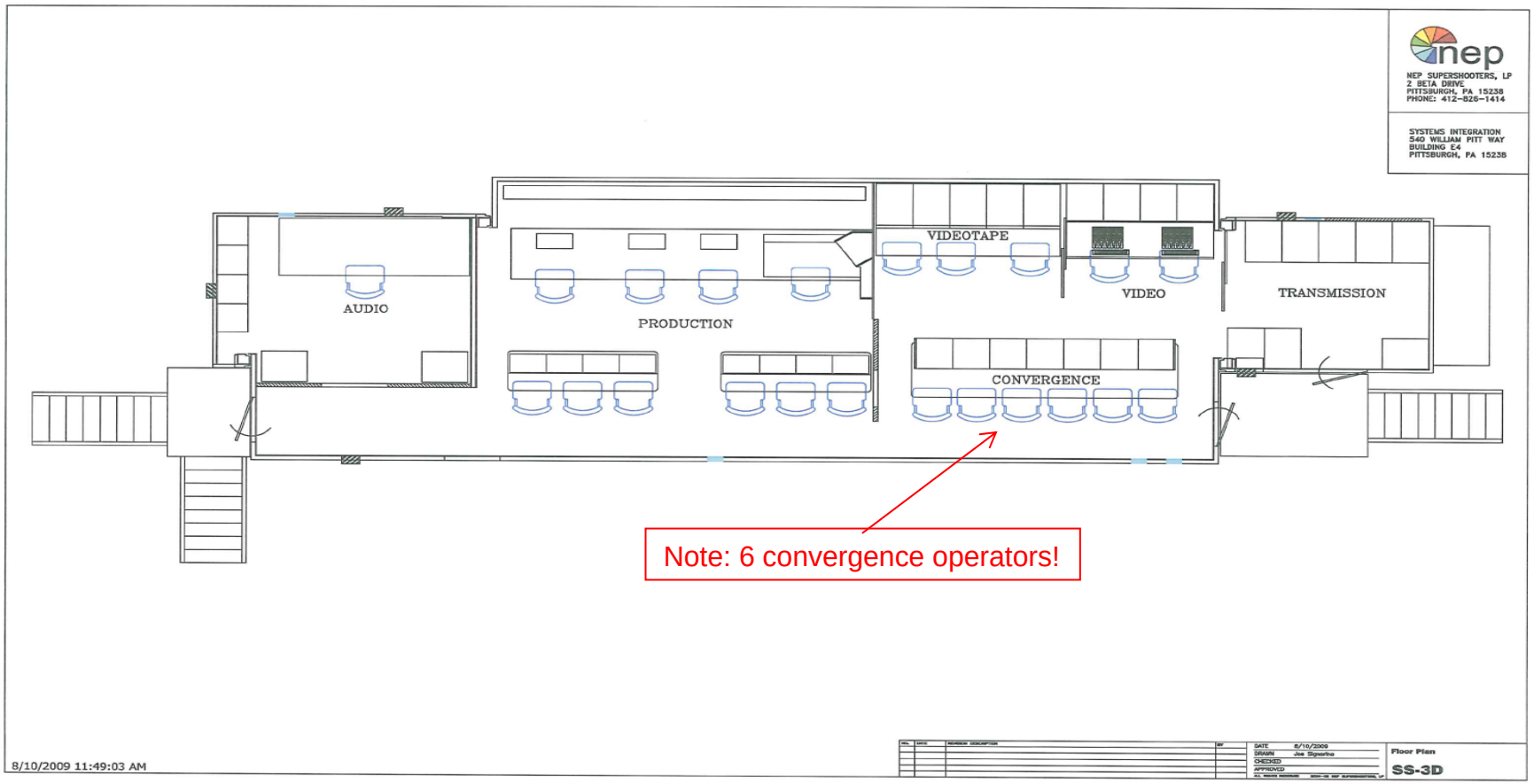
- Who's Deploying 3DTV?
  - Comcast & Cox Cable
    - The Masters

  - Verizon
    - FiOS
    - By holiday season

3DTV Domestic Update

- Who's Deploying 3DTV?
  - ESPN
    - 25 World Cup games
    - Minimum 85 sporting events all in 2010 (June 11 on)
    - College basketball, college football, BCS National Championship game in January 2011
    - Exclusive sponsor: Sony

Remote 3DTV Production



3DTV in the US

CBS

- Final Four of NCAA Basketball Tournament
- US Open Tennis
- PGA Championship

Fox

- Airing sports beginning in a few months

Turner

- NBA Basketball, animation, other content

PBS

- Showing interest

3DTV in the US

NBC

- Farther behind, but think 2012 Olympics at a minimum

ABC

- Focusing on ESPN3D, but could translate to broadcast network

Discovery

- 3DNet launching this year

3DTV in the US

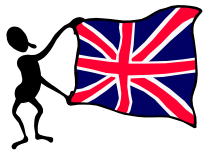
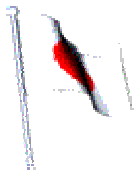
CABLEVISION

Cablevision – first live stereoscopic broadcast to the home, powered by Harris equipment

3DTV Worldwide

France		Canal+ Orange
Portugal		Zon Multimedia
Germany		Sky Deutschland
Spain		Canal+ Spain Hispasat TV3
Poland		Cyfra+ Dialog
Finland		Welho

3DTV Worldwide

UK		BSkyB BBC ITV Virgin
Brazil		TV Globo NET Servicios
Japan		Sky Perfect WOWOW J:com
Korea		CJ HelloVision TU Media Skylife OTA Trials

3D at CES

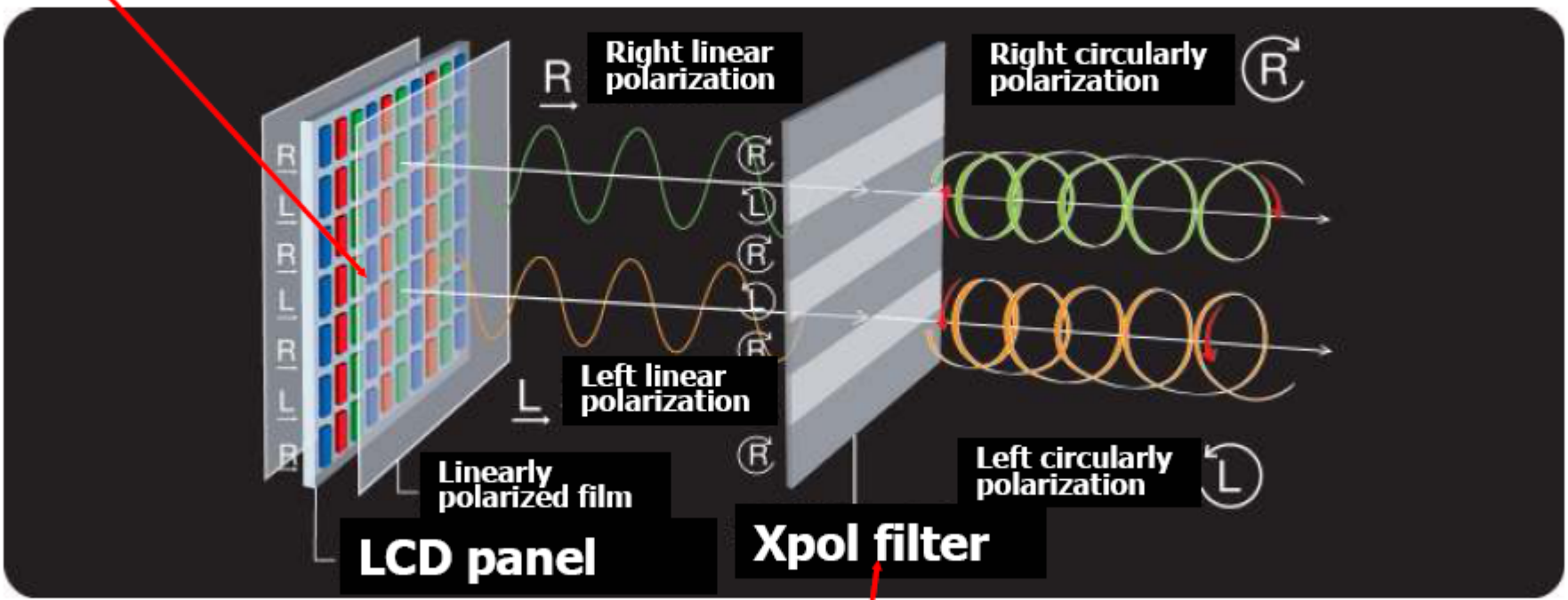
- Samsung and Toshiba – live 2D-3D conversion on the TV
  - All Samsung 3D sets have this.
  - Analagous to upconversion of SD to HD, but worse
  - Still, very impressive technologically
  - Experience dependent on content – some looks great, some not.

3D at CES

- Internet VOD 3D

How Does 3DTV Work?- Xpol

Image displayed alternatively
(Odd: for right eye, Even: for left eye)

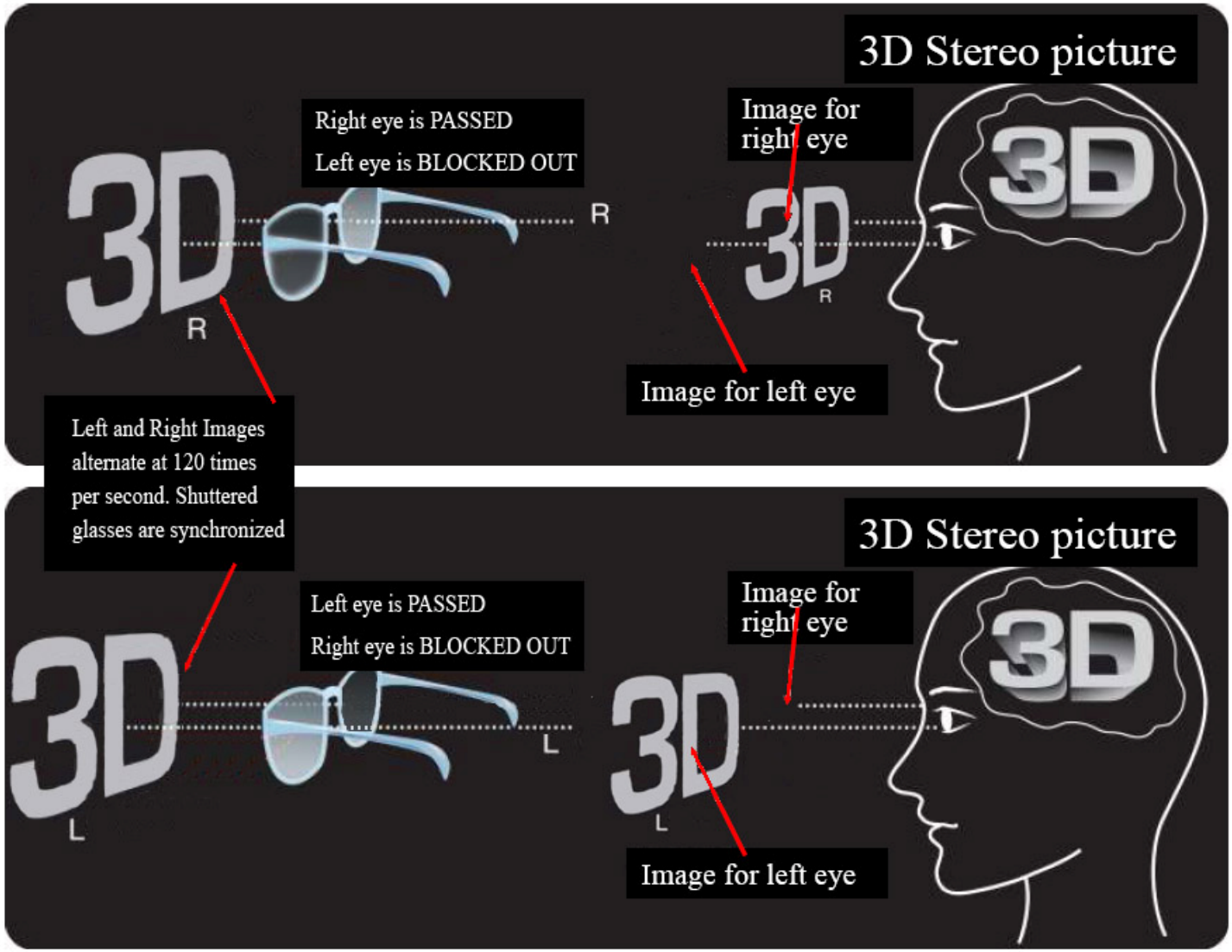


Xpol filter converts linear to circularly

How Does 3DTV Work?- Shutter

Left and Right images are displayed sequentially. IR synchronized glasses pass only the right image to the right eye and left image to the left eye.

No loss in resolution!!!!!



How Does 3DTV Work?- Shutter

- Frame-Sequential (temporal compression)
  - Full resolution
  - Frame rates of 120Hz or more (up to 480Hz currently)
  - TV sets inexpensive (maybe a few hundred more)
  - Active shutter glasses
    - Expensive, but dropping rapidly
    - Need to be recharged
    - A little less fashionable
  - Not 2D compatible
  - Works best in a dark environment
  - Picture tends to look darker (each eye is blocked more than ½ the time)
  - Used for gaming, available on laptops

- Cameras
  - Two lenses side by side – traditional approach
    - Panasonic - $21K twin lens professional camcorder avail Q3…consumer camcorders to follow

- Cameras
  - Two lenses with mirror (beam splitting) – when there isn't enough room for a side by side rig

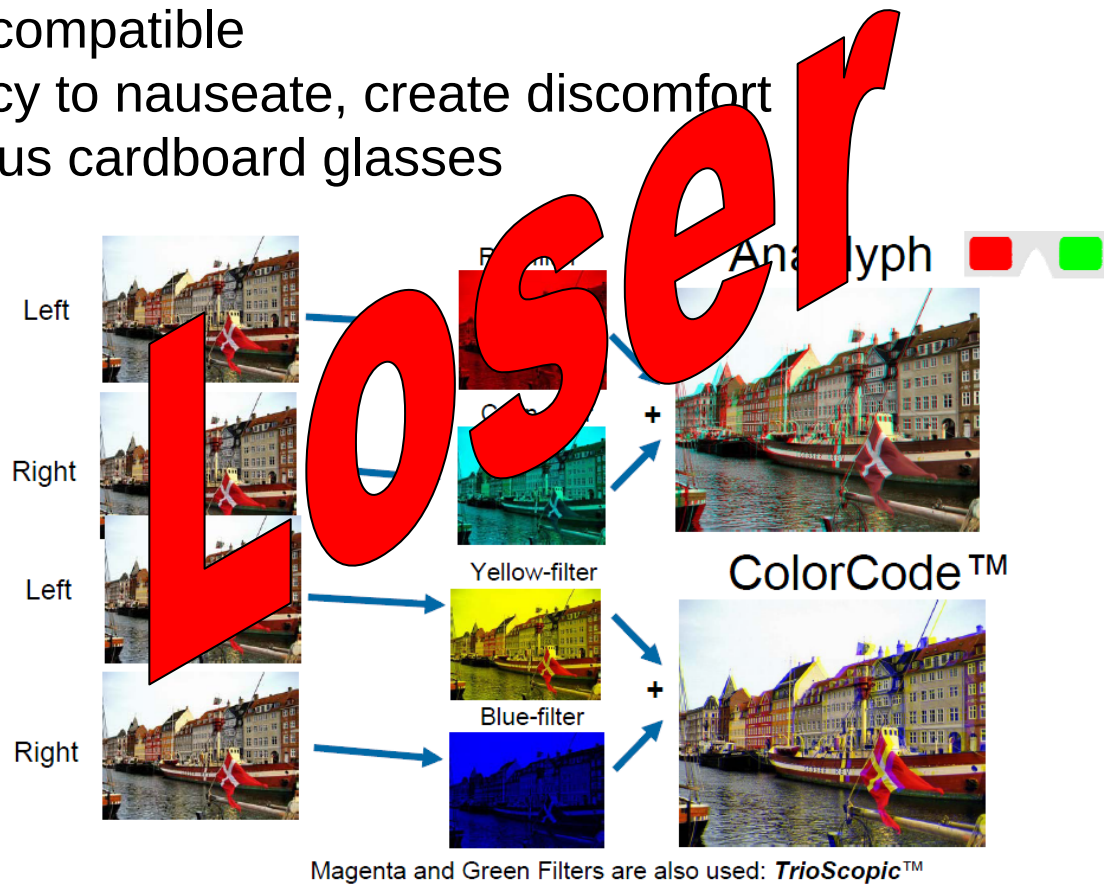
- Cameras
  - Single lens camera (Sony)!

- Sports Production
  - Far fewer cameras needed for 3D vs 2D
  - Far fewer cuts needed to cover (single camera on single play is common)
  - Greatly increased router size needed
  - Today: separate production teams
  - Tomorrow: hybrid approach – share resources

3D Update

- Formats, formats, and more formats…
  - Winners and losers already becoming apparent (to some degree)

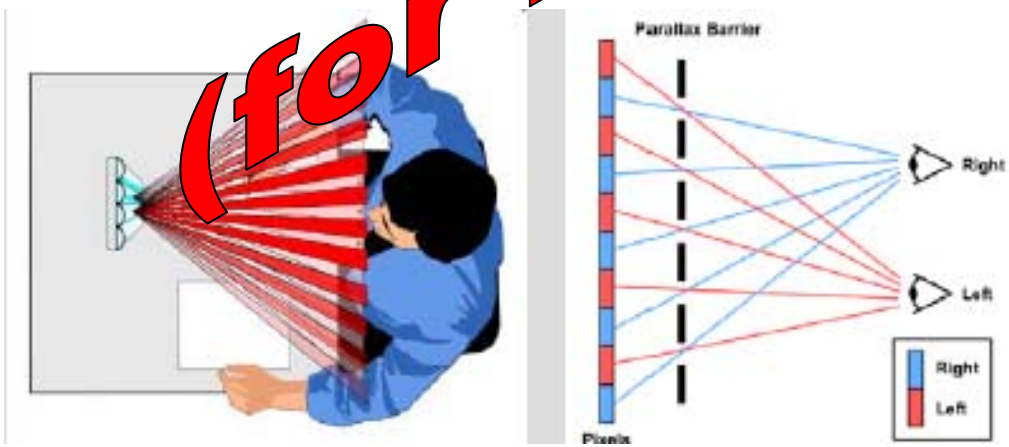
- Anaglyph & ColorCode
  - Use different colors for L & R
  - Inferior quality
  - Not 2D compatible
  - Tendancy to nauseate, create discomfort
  - Ridiculous cardboard glasses



Magenta and Green Filters are also used: ***TrioScopic***™

- Glasses-free (autostereoscopic)
  - Mobile phones – looks fine on a small screen, smaller bandwidth impact
  - Digital signage (people are not going to put on glasses to see 3D when shopping)
  - Home use - perhaps 10 years away – Philips (early proponent) stopped pushing this publicly
  - Issues: bandwidth, quality, head placement, etc.

Loser (for now)

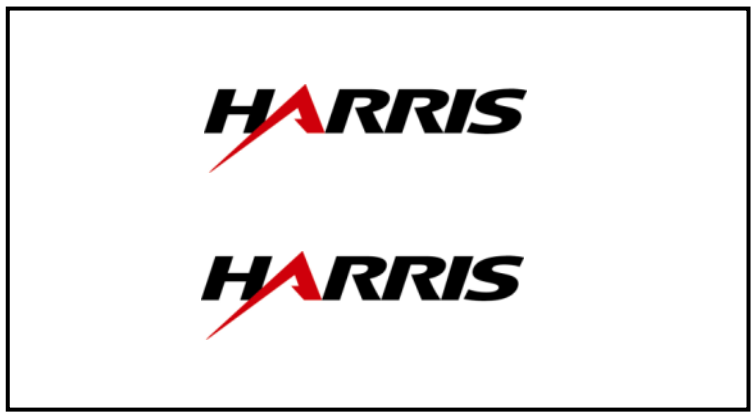


3D Distribution – side by side

- Side-by-side
  - Compresses horizontal resolution, which we have more of.
  - Works well on lower bitrates
  - Enhancement layer option to improve resolution

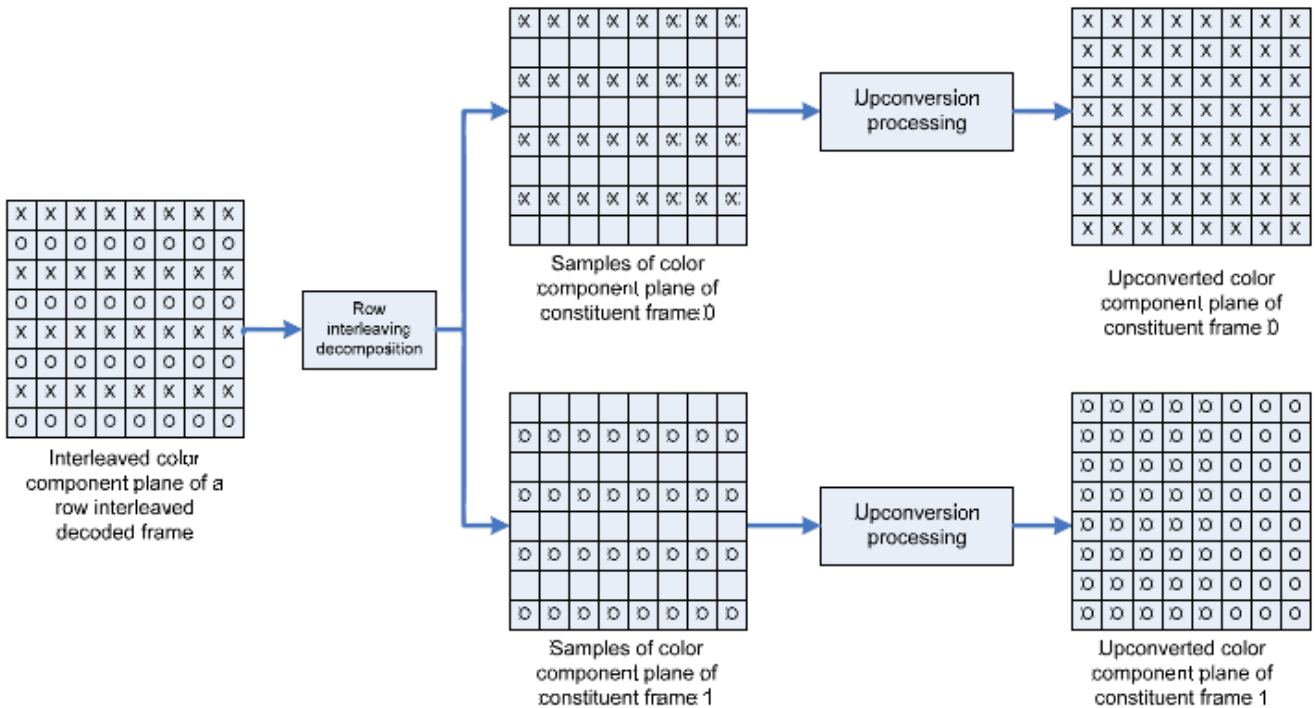
3D Distribution – Over-Under

- Over-Under (also called Top-Bottom)
  - Reduces vertical resolution (which you have less of) – problem for graphics, captions, subtitles
  - Doesn't work well for 1080i



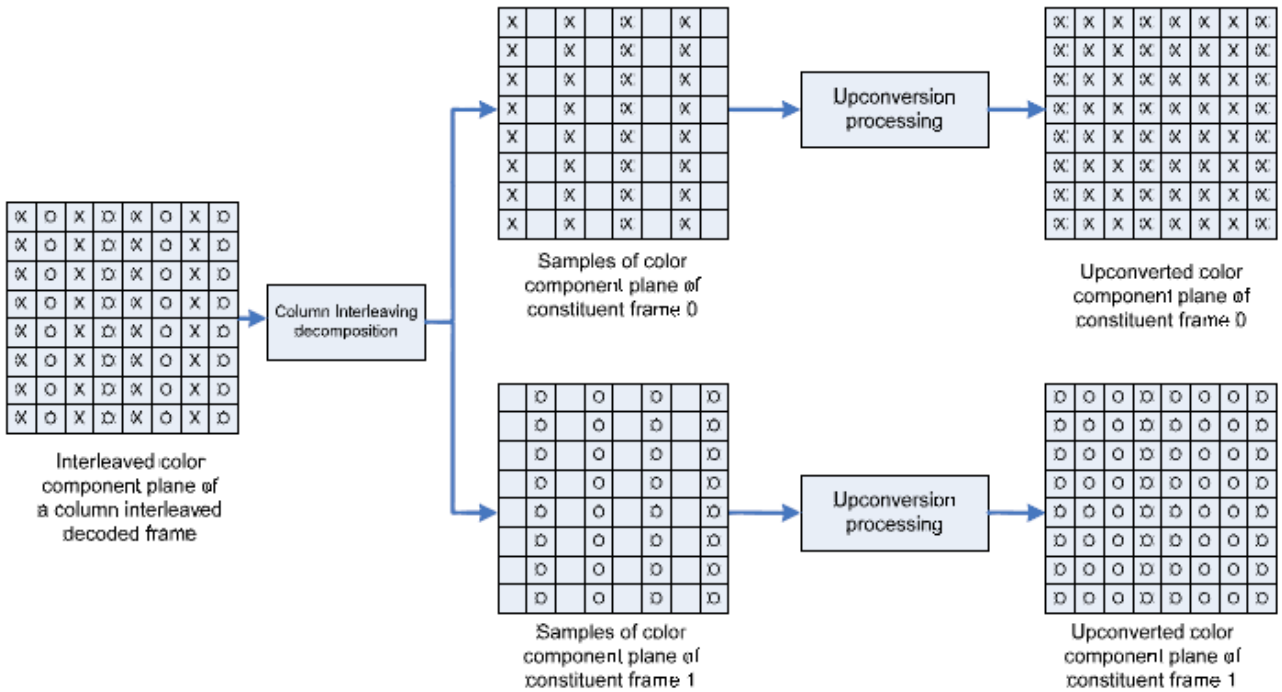
3D Distribution – Interleaved

- Line-Interleaved (a.k.a. row interleaved)
  - Loss of vertical resolution
  - Compression artifact issues



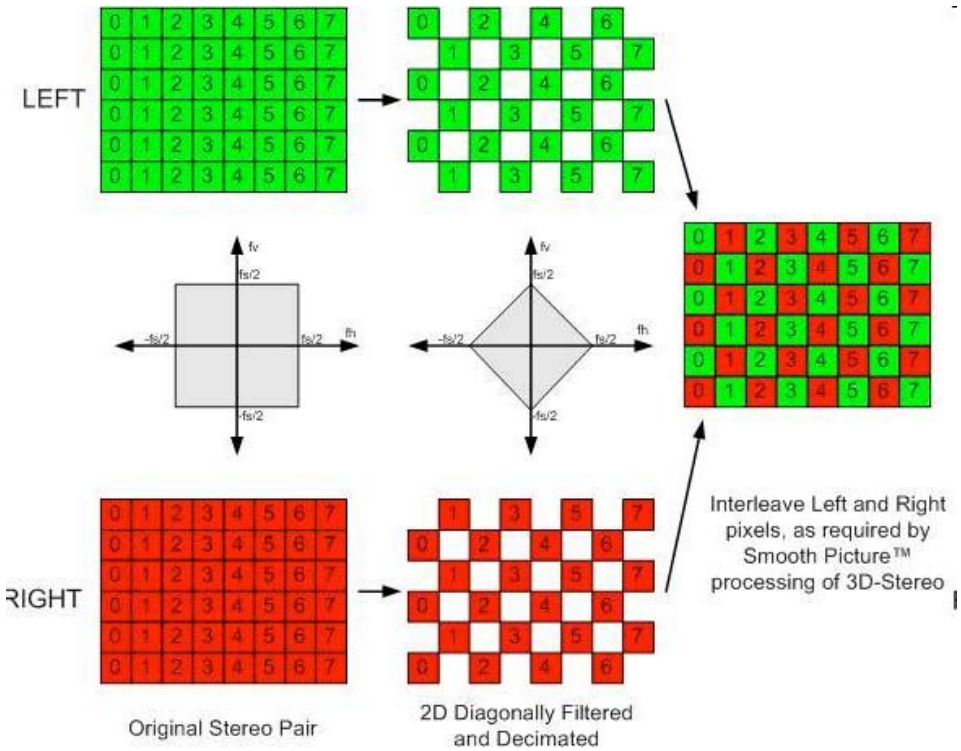
3D Distribution – Interleaved

- Column-Interleaved
  - Loss of horizontal resolution
  - Compression artifact issues



3D Distribution – Checkerboard

- Checkerboard
  - Halves both horiz/vert resolution
  - Difficult to compress, scaling problems, etc.



3D Update

- Frame-Compatible (spatial compression)
  - Over-under (Cable)
  - Side-by-side (BSkyB, DirecTV)
  - Line-interleave
  - Column-interleave
  - Checkerboard

  - When used on TVs, viewed with polarized glasses
    - RealD
    - Very inexpensive (~$1)
    - Fashionable
  - Works fine in large environments with ambient light (think bars, restaurants)
  - Not 2D compatible
  - Half-resolution (can be improved)
  - TV sets more expensive (technology, licensing)

- Frame-Sequential (temporal compression)
  - Full resolution
  - Frame rates of 120Hz or more (up to 480Hz currently)
  - TV sets inexpensive (maybe a few hundred more)
  - Active shutter glasses
    - Favored by Dolby
    - Expensive, but dropping rapidly
    - Need to be recharged
    - A little less fashionable

  - Not 2D compatible
  - Works best in a dark environment
  - Picture tends to look darker (each eye is blocked more than ½ the time)

3D Distribution – 2D + Difference

- 2D + Difference/Delta/Depth/Metadata
  - Basis of MPEG H.264/AVC MVC
  - TDVision
  - Full-resolution left eye
  - Right eye view constructed using metadata
  - Only format that's inherently 2D compatible (old displays simply ignore the 3D metadata)
  - Roughly 1.35x regular HD bandwidth
  - Good picture in 7 Mbps

Distribution and Display Formats

- Which format is the winner?
  - For distribution to consumers (non Blu-ray):
    - Today: frame compatible
    - As ROI becomes evident, perhaps 2D+Delta/MVC, or other full-resolution per eye
  - For display:
    - Today: frame sequential with shutter glasses (dominant at CES)
    - As prices drop, maybe frame compatible with polarized glasses

Things to Ponder

- Best-suited content?
- Production costs
- Graphics/subtitles/caption considerations
- Distribution bandwidth versus quality
- What about ad-supported channels?

Ad-Supported Channels

- First 3DTV channels not ad-supported
- Issue will be faced sooner than you think
- Will we see 3D ads soon?
  - Some out there
  - Harris working on educating Adv/Agy community
- Can you charge a premium for 3D ads?
- Meanwhile…take 2D content and float it a little in front of screen plane.
- Automated 2D-3D conversions not the whole answer

3D Standards Activities

- SMPTE Activities
  - Dealing with 3D Home Master
    - Common professional format for both live and recorded content.
  - Four active ad hoc groups:
    - Image Format
    - Graphics
    - Subtitling
    - Metadata
  - Goal of June 2010 for documents out of these groups

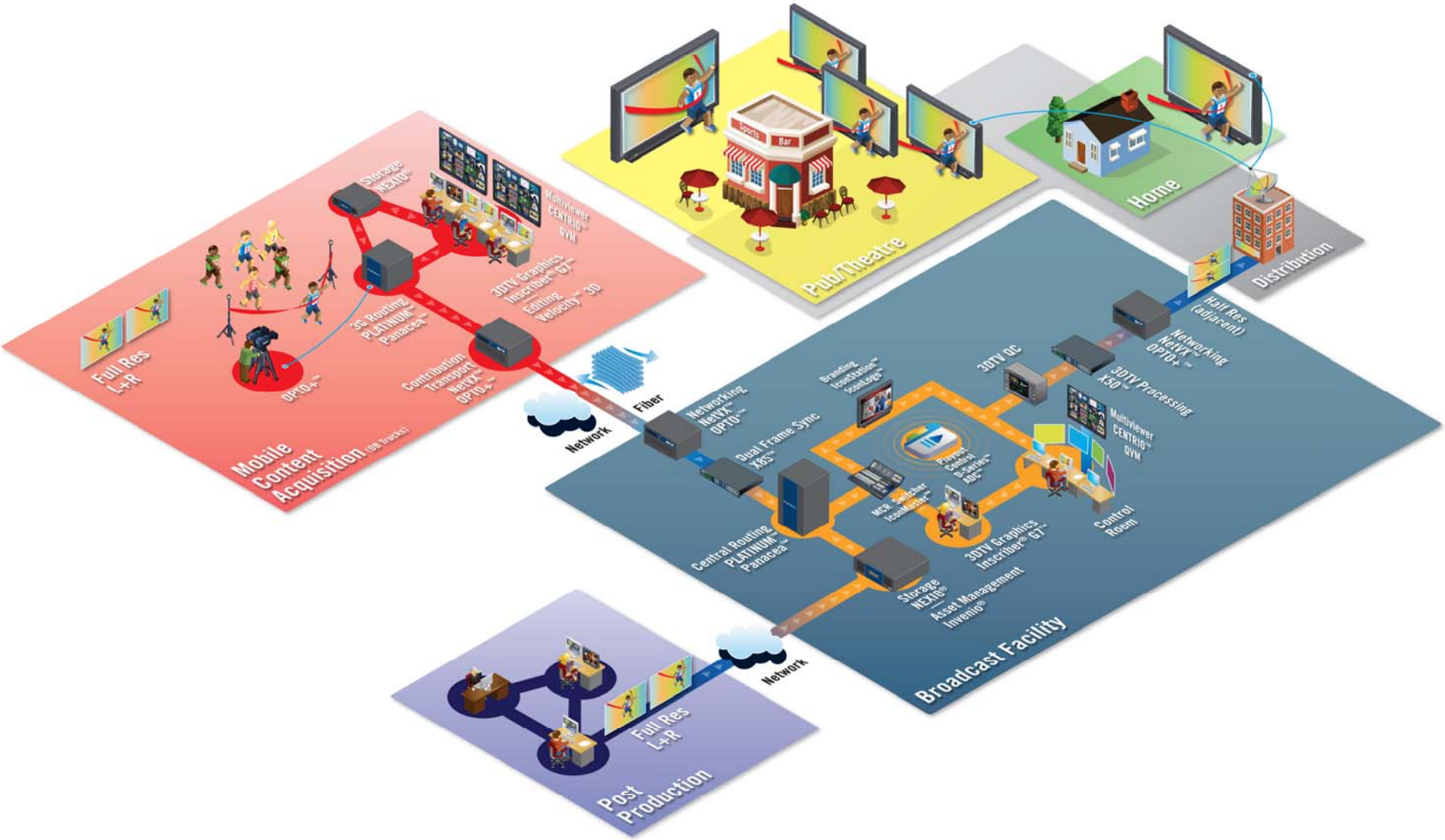
3D Standards Activities

- ATSC Activities
  - Originally part of ATSC 2.0 plan
  - On hold right now, but could re-surface
  - Examining fitting more bits into each station's allocated frequency
  - Work on NRT progressing – more likely for 3D distribution than traditional linear broadcast
  - Mobile 3D possible, but need to get basic MobileDTV up and running first.

3D Standards Activities

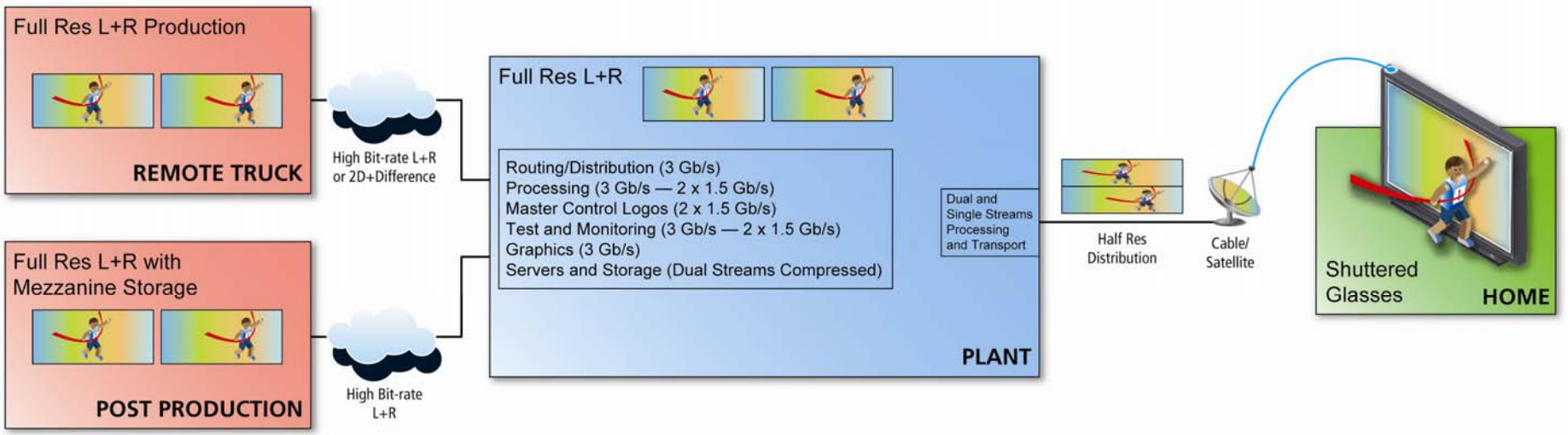
- SCTE Activities
  - Active working group
  - Working closely with CableLabs and MPEG
  - Unique challenges in cable environment (eg. STB)
  - Constituents moving forward

3DTV – Workflow



3D Signal Flow

- 3 Gb/s is preferred to keep signals together
  - Two 1.5 Gb/s packed under SMPTE 372 to make 3 Gb/s
  - expect a mix of two 1.5 Gb/s and 3 Gb/s for a while
  - Difficult to guarantee the sync-up of two 1.5 Gb/s feeds



Harris Differences

- Many other vendors are offering 3DTV point products
- We look at entire “glass to glass” ecosystem
- We are not new to this
  - Government 3D work for many years
  - One of the first to take this seriously
    - SMPTE 3DTF founding member “way back” in 2008

Harris' 3D Workflow Overview – short-term

Our Routers can treat L/R dual-link signals as a "pair" and route them together to dual-link destinations in single control transactions frame-accurately..

The Harris Multiviewer products provide a number of 3D monitoring options.

The IconMaster Master Control processor can be configured in a Left/Right slaved configuration, enabling dual-link full master control processing in 3D.

X50-3D takes dual link, converts to HDMI

Also supering L/R for convergent 2D testing

NetVX Dual link encoder/decoder

Dual-Link

HDMI

Single-Link 1080i

X85 matched synchronization of the left-eye and right-eye signals, recovering from phase errors that creep in while using traditional contribution solutions for the separate signals.

The Video Networking product family supports a number of transport methods for single-link and dual-link signals.

The X50-3D can output 1080i single-link in side-by-side and top-and-bottom modes. In addition, the X50-3D supports HDMI output to several common 3D displays for monitoring purposes.

The NEXIO Server family can do coordinated ingest and playout of an L/R pair

.

The Velocity series of editors will support L/R editing

The Inscriber Graphics product family will support full-resolution live dual-link graphics rendering in the new G7-3D product line; Single-Link 1080i is also supported in some modes.

Harris 3DTV Products

Routing (Platinum/Panacea)

- 3G of course
- Marriage of dual channels in control system

X50-X85

- Dual/Single Link
- HDMI for 3D and supering for 2D viewing
- 3D Timing/Sync/Proc functions – can frame sync two 1.5Gbps streams

Servers (Nexio)

- slaved ingest and playout for left and right channels

Harris 3DTV Products

Master Control & Branding (IconMaster)

– Slaved MC operations using two units with single control panel for left and right channels
– 3D logo insertion

Automation

– Can control two streams

Networking/Encoding (NetVX)

– Demoing dual channel using X85s for dual sync up

Harris 3DTV Products

Monitoring (Multiviewer)

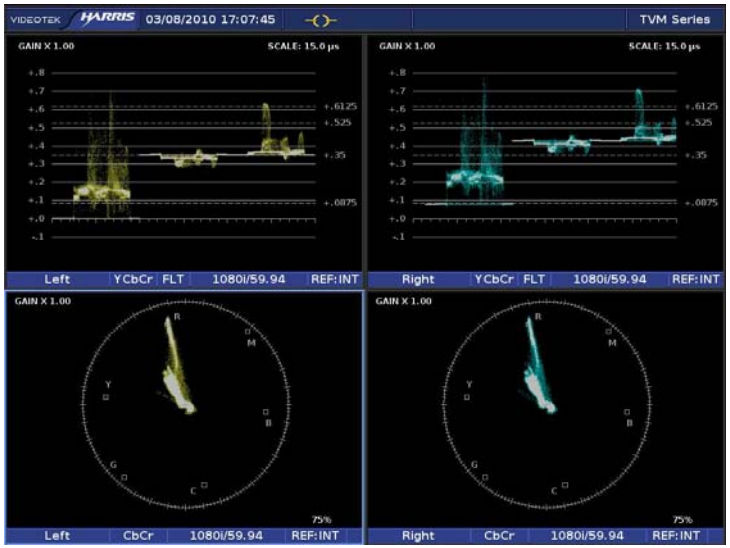
– 2D and 3D monitoring

Editing (Velocity)

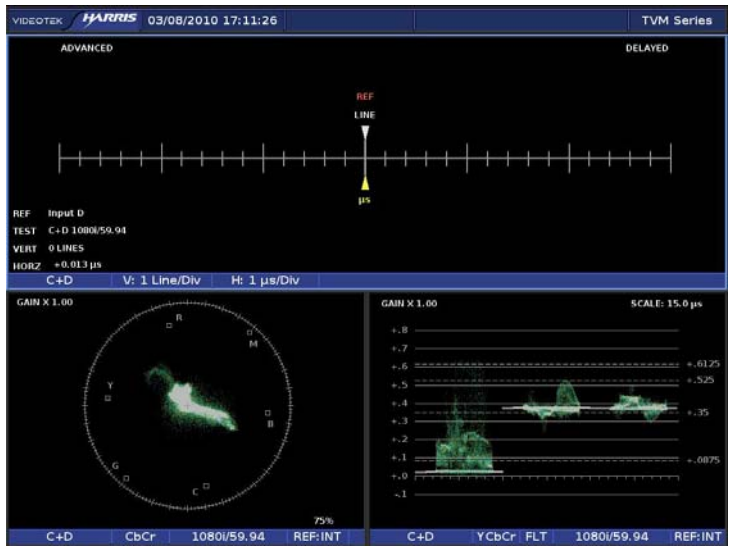
– Working on changes to the editor to support left and right channel editing, initially from dual link captured material

Harris 3DTV Products

Test & Measurement



Left Eye/Right Eye Luminance/Chrominance Measurement



Overlay with Position Measurement, Luminance/Chrominance Measurement

Harris 3DTV Products

Graphics (Inscriber G7-3D)

– Working with Nvidia card now, private customer demos underway in Toronto

– Leverages all the functionality of the currently shipping Gscribe 7.0 software.

– Realtime 2D and 3D graphics in 3D stereo

– Output dual link 1.5G L+R HD SDI

Harris 3DTV Products

Graphics (Inscriber G7-3D)

– Also single link side-by side and top-bottom and field sequential

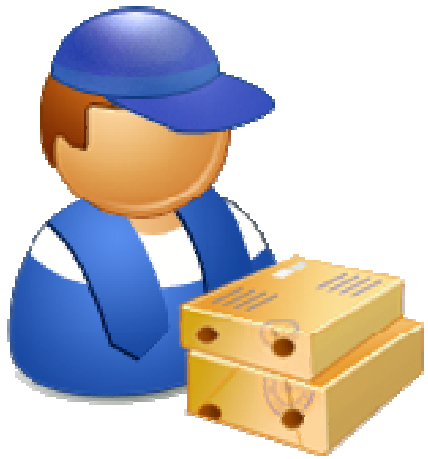
– Dynamically adjust Z depth and focal depth in real time

– Preview stereo 3D directly on the. design canvas

– Supports pre-rendered 3D content Playback (stereo AVIs, MOVs etc)

Product Deliverability

- All products we are discussing are available today!



- **Our Rivals are so far behind…**

- Never mind…

Conclusions

- 3DTV is moving forward at an unprecedented pace
- Predictions are difficult and dangerous
- Harris is the only vendor offering end-to-end 3DTV solutions now, rather than simply a point product or two
- We offer top notch solutions for today's HD needs, which are also 3DTV-capable if you need it tomorrow

Thank You

Chris Lennon
CTO Group
Harris Corporation

clennon@harris.com