Society of Cable Telecommunications Engineers

30TH ANNIVERSARY

SCTE CABLE-TEC EXPO '13

OCTOBER 21-24 / ATLANTA, GA

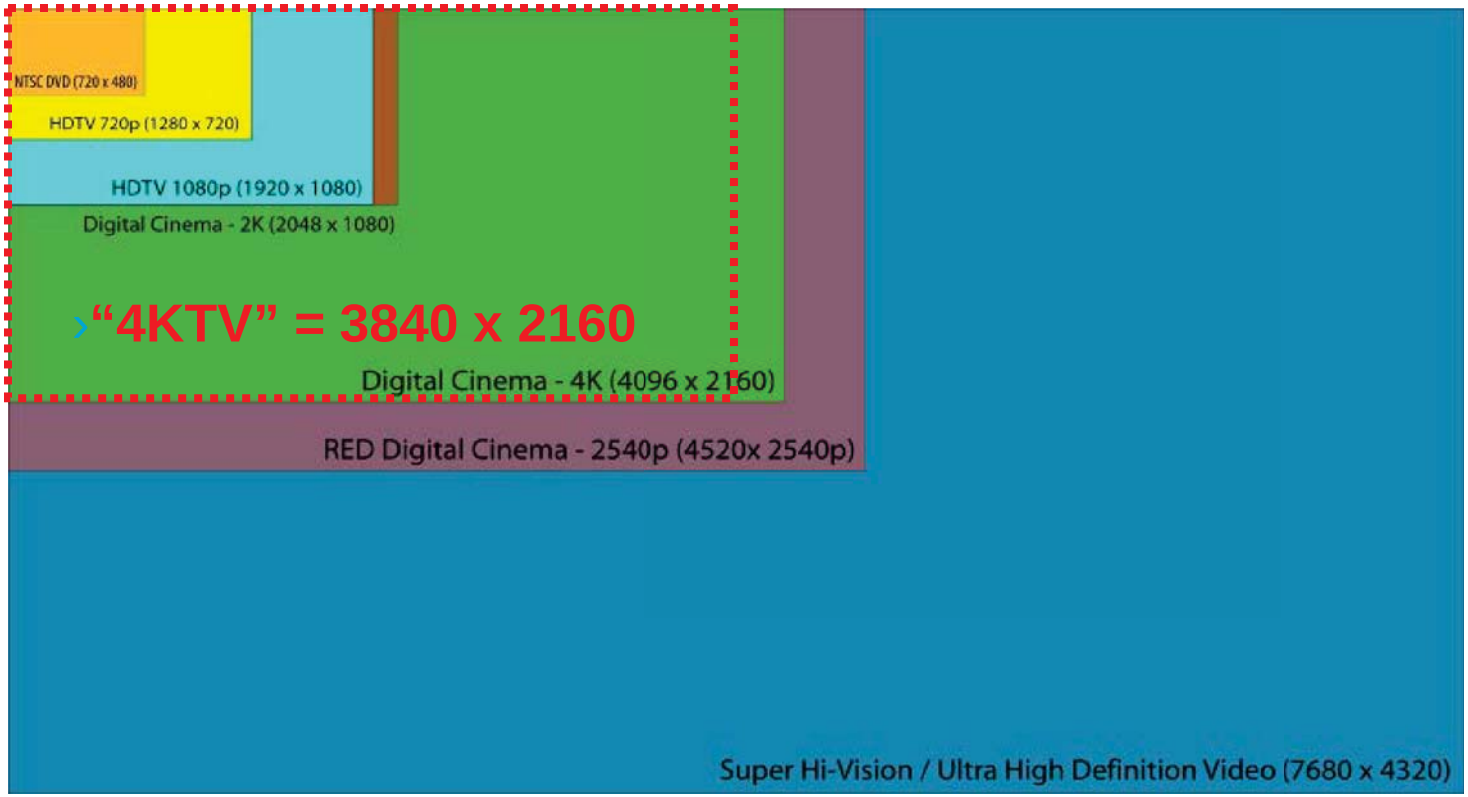
The Future of 4K UHDTV – Examining Methods to Acquire, Exchange and Distribute High Quality Content

Matthew Goldman

Senior Vice President, TV Compression Technology

Ericsson

What is 4KTV? UHDTV?



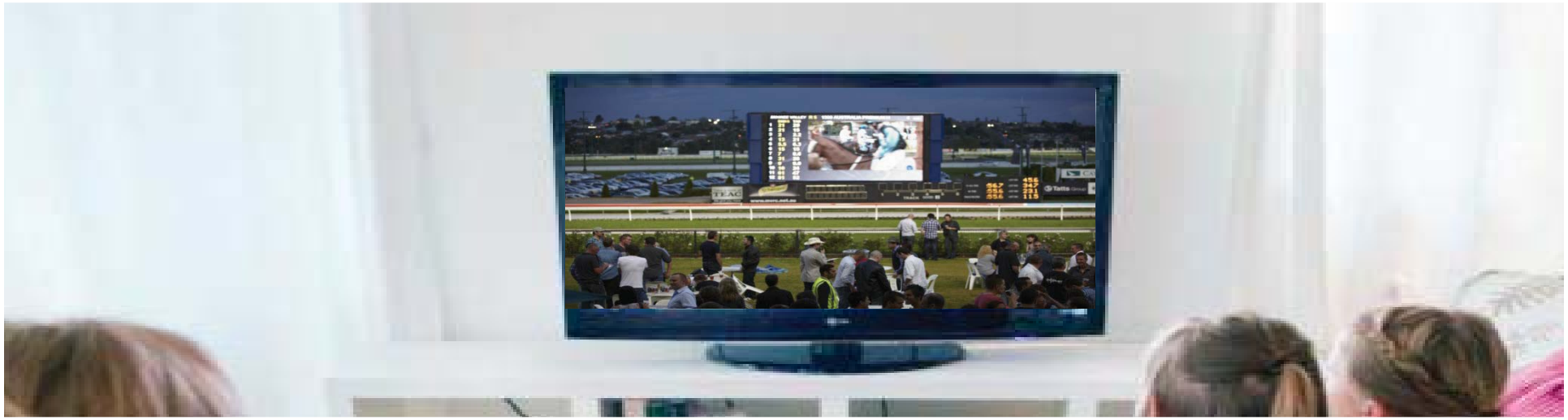
In context of broadcast television, “4KTV” is UHDTV Level 1 or 4K UHDTV

What is “True” or “Full” 4K UHD?

UHDTV is effectively 4x HD spatial resolution but that’s not the entire story …

Visual Quality - Immersive Experience

Central field of vision - 90°

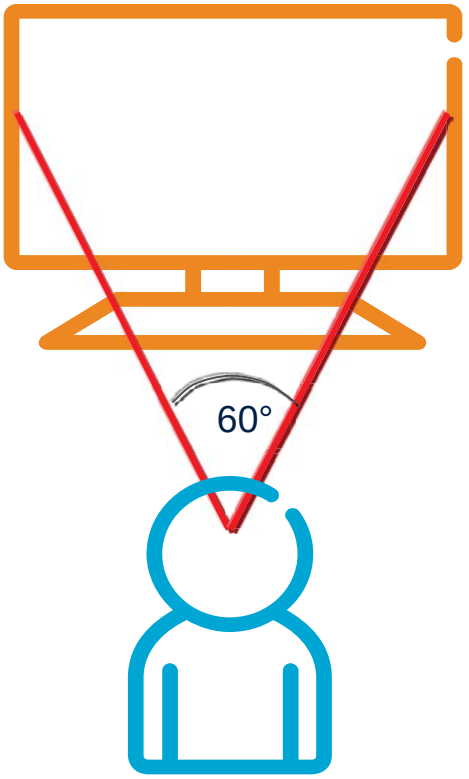


Visual Quality - Immersive Experience

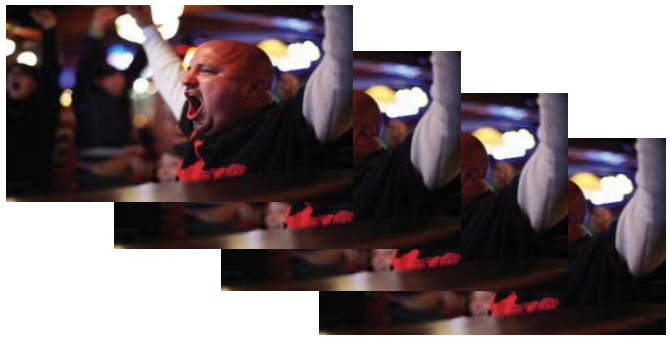
Central field of vision - 90°

Visual Quality – Frame Rates

- UHDTVs' field of view will occupy typically 60°
  - As a result of increased screen size
- Motion judder is caused by angular change
  - Larger displays mean a need for increased frame rate
  - A function of linear TV size
- 4K UHDTV
  - Will benefit from 2x frame rate versus HD
    - Therefore 50 fps and 59.94/60 fps are ideal
  - Higher frame rates are being debated …
    - Motion judder concern has been demonstrated
    - Also some risk of impairment from camera CCD noise
    - 100-150 fps currently under industry research



High Frame Rate



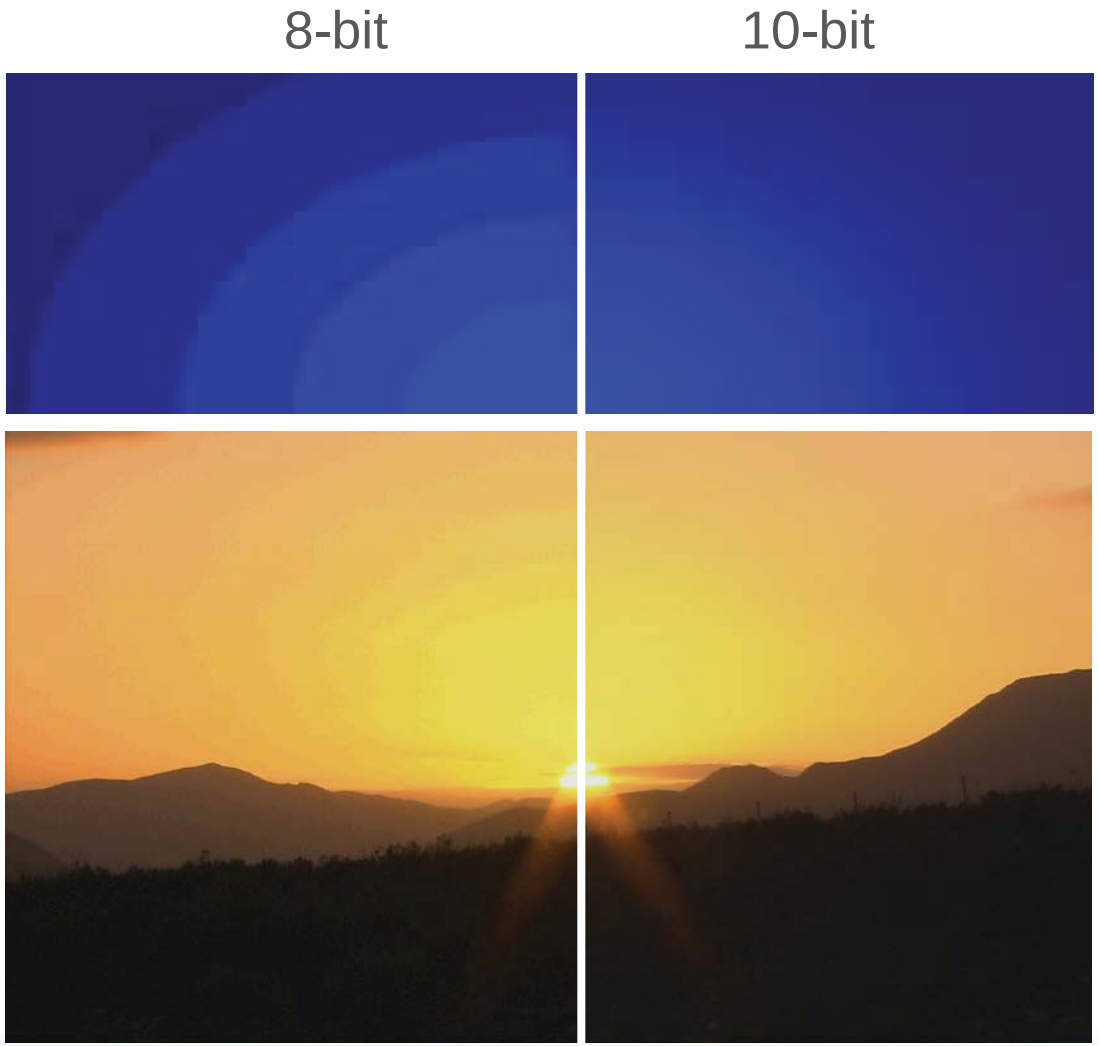
25/30 frames/sec

Minimum
50-60 frames/sec …

… to minimize motion judder for sports and other content with complex motion

50/60 frames/sec

UHDTV likely to be 10-bit to home



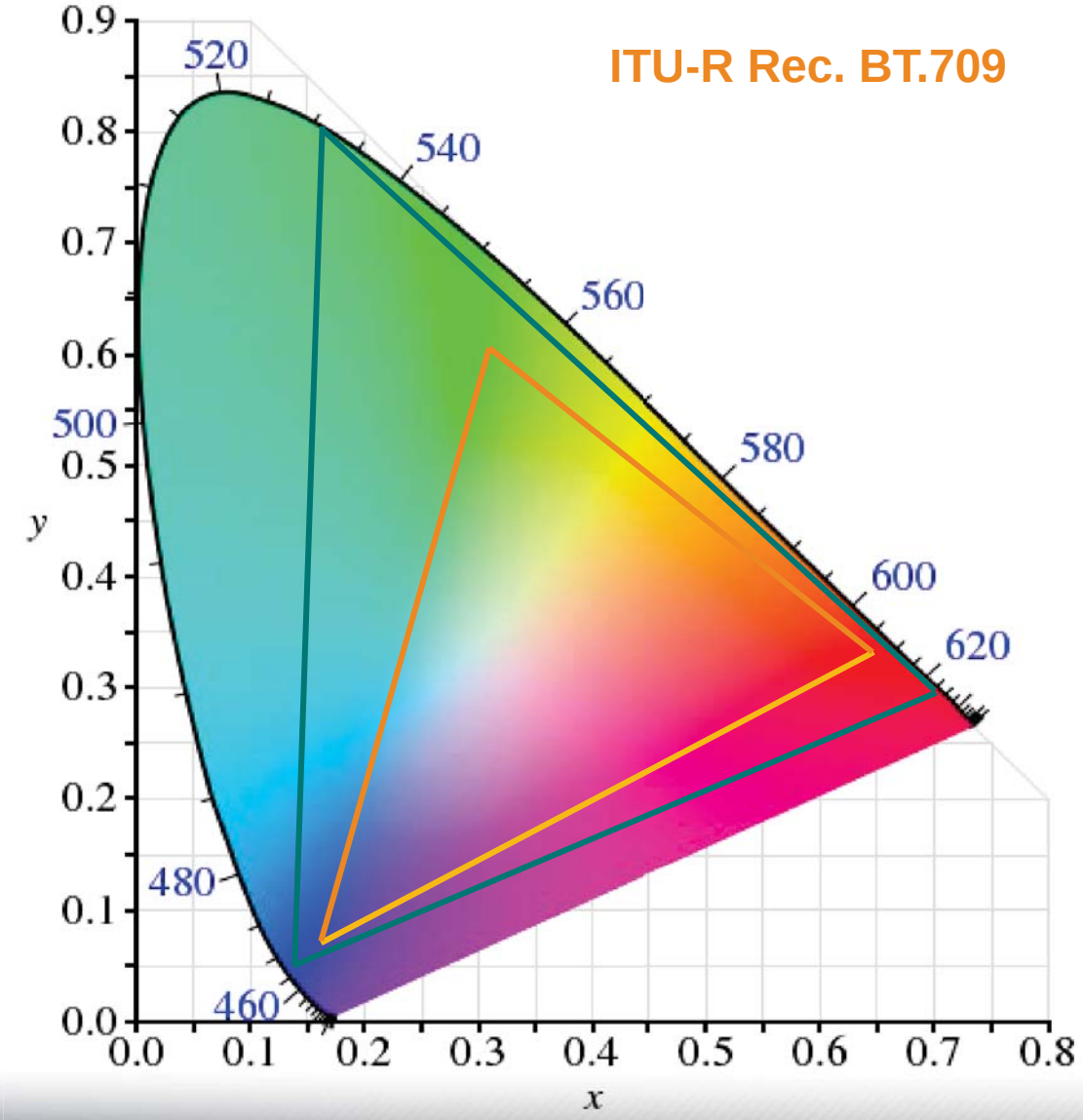
- Banding (posterization) with 8-bit, especially in plain areas
  - –Sky, backgrounds, graphics, logo
  - –More noticeable with slow changes, such as fades

10-bit operation does not cost bitrate

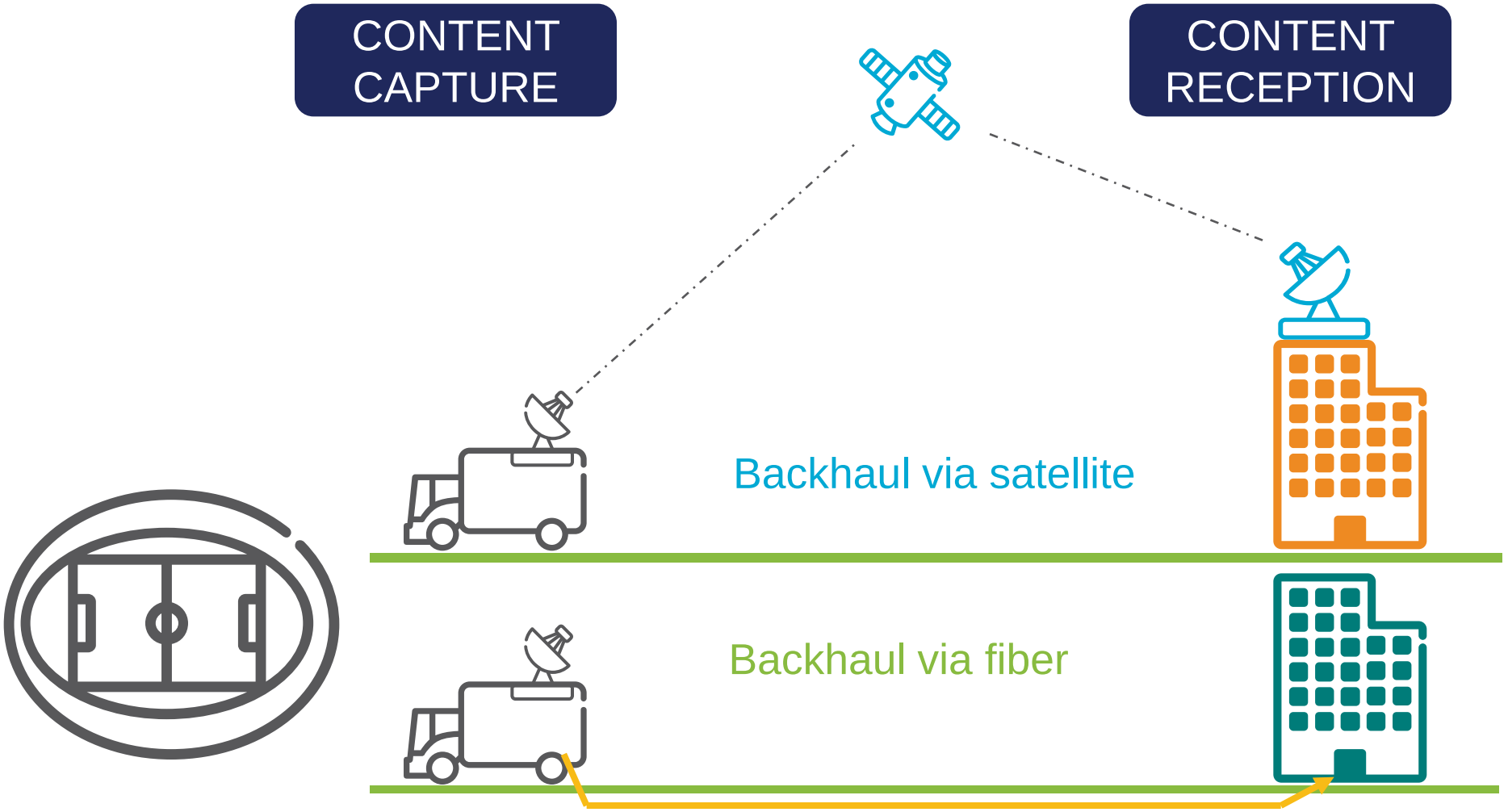
Colorimetry

Expanded color space for more realistic presentations

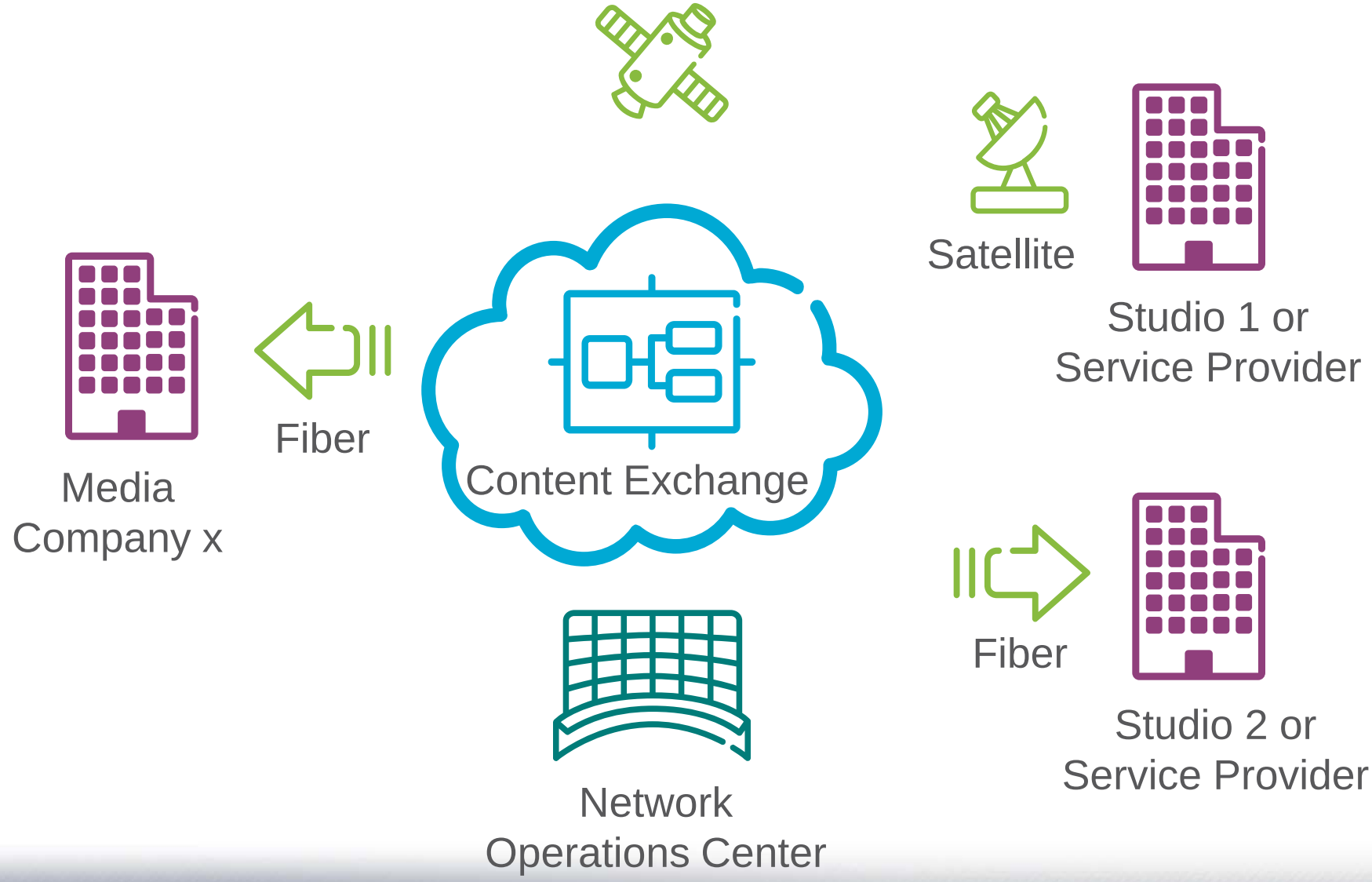
- UHDTV can offer more realism via color
  - But, we need technology with the right color space
- Quantization of levels
  - 10-bit is critical



Content Acquisition



Content Exchange / Distribution



Transporting Uncompressed Video

Challenging due to higher bitrates …

- Single link 3G-SDI does not support any 1080p50/60 formats beyond 10-bit 4:2:2
- High Dynamic Range and 4:4:4:(4) production requires multi-link 3G-SDI
- High Frame Rate 2K D-Cinema standardizing 96, 100 and 120 fps
- 4K D-Cinema and UHDTV-1 have four times the pixels
  - Sixteen times for UHDTV-2
- All progressive scanned, doubling the bitrate vs. existing interlaced formats
- Stereoscopic 3D doubles bitrates (Left Eye and Right Eye channels)

Formats & Interfaces

System Nomenclature	Horizontal Pixels	Vertical Pixels	Frames per Second	Total Payload	
				10-bit 4:2:0 10-bit 4:2:2	12-bit 4:2:0 12-bit 4:2:2 12-bit 4:4:4 10-bit 4:4:4:4
4320p60 / 59.94	7680	4320	60	48 Gbps	96 Gbps
4320p50	7680	4320	50		
4320p30 / 29.97	7680	4320	30	24 Gbps	48 Gbps
4320p25	7680	4320	25		
4320p24 / 23.98	7680	4320	24		
2160p60 / 59.94	**3840 / 4096**	**2160**	**60**	**12 Gbps**	24 Gbps
2160p50	3840 / 4096	2160	50		
2160p48	4096	2160	48		
2160p30 / 29.97	3840 / 4096	2160	30	6 Gbps	12 Gbps
2160p25	3840 / 4096	2160	25		
2160p24 / 23.98	3840 / 4096	2160	24		
1080p60 / 59.94	1920 / 2048	1080	60	3 Gbps	6 Gbps
1080p50	1920 / 2048	1080	50		
1080p48	2048	1080	48		

SMPTE Study Group on UHDTV Ecosystem –> Address open areas

- Frame Rate
  - HDMI 1.4 limited to 30 fps for 4K UHDTV (3840x2160p)
  - UHDTV needs higher frame
  - Current production standards go to 120 fps
  - Research extends to 300 fps and beyond
- Color Space
  - New color space/primaries (ITU-R Rec. 2020)
  - Support legacy HD primaries (ITU-R Rec. 709)
  - Color space conversion might be tricky

SG UHDTV Ecosystem (2)

- Real Time Interface
  - Bandwidth increase requires multi-link SDI
    - 2160p 60 fps (10-bit 4:2:2) = 12 Gbps (4x 3G SDI)
    - 2160p 120 fps (10-bit 4:2:2) = 24 Gbps (8x 3G SDI)
    - 2160p 120 fps (12-bit 4:4:4) = 48 Gbps (16x 3G SDI)
  - SMPTE Multi-Link efforts
    - ST425-5: Quad Link 3G
    - ST2036-3: Single/Multi-Link 10G
    - FCD ST2062-1: Single-Link 25G (20G payload)
  - UHDTV in facility needs single wire interface
  - Move to Video over IP or Ethernet (ST2022, AVB)?
  - Joint Task Force on Networked Media (SMPTE, EBU, VSF)

SG UHDTV Ecosystem (3)

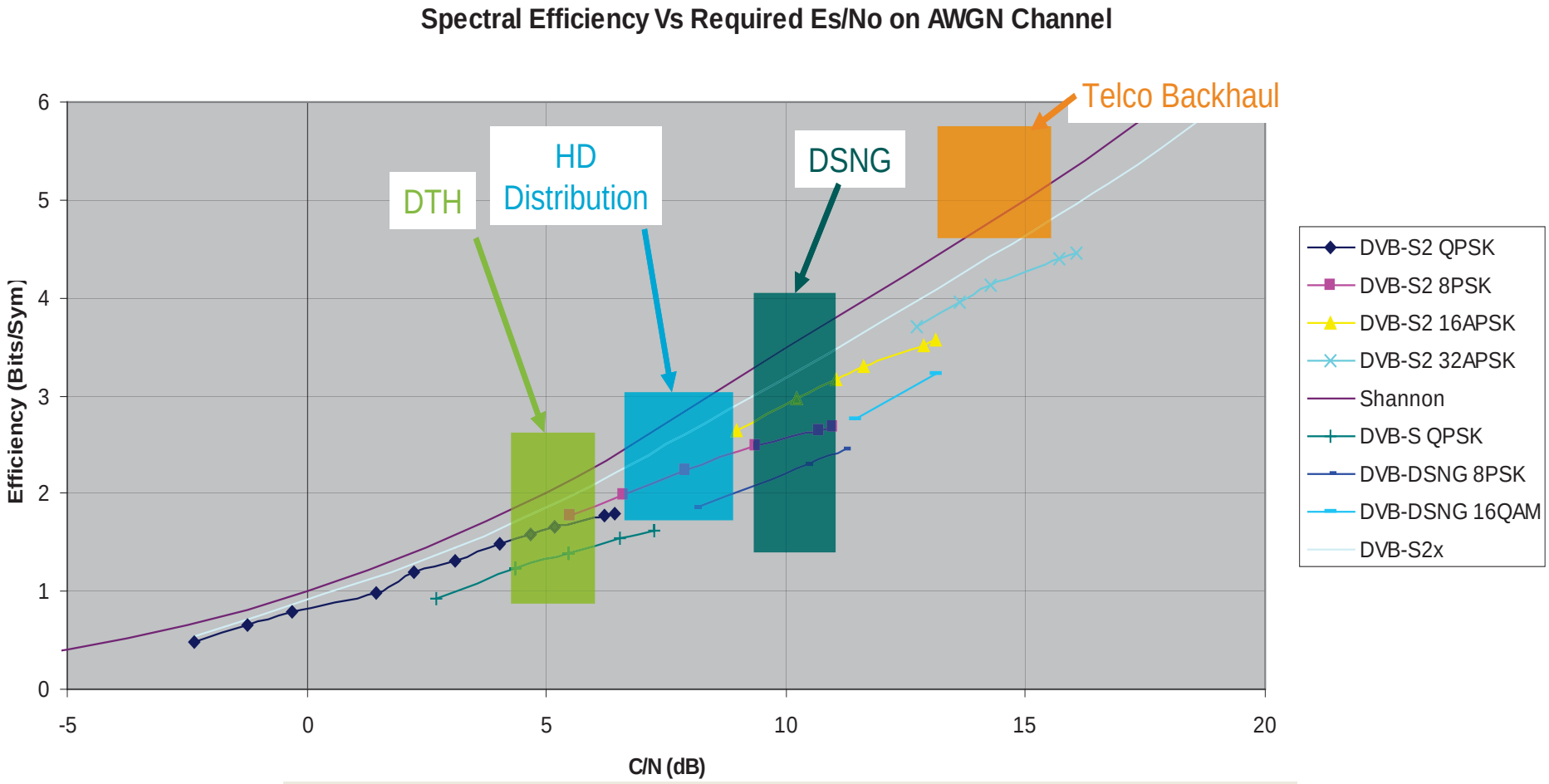
- Mezzanine Compression
  - Enable UHDTV on existing HD infrastructure
  - Real-time interface needs mapping to SDI or IP
  - Many compression options possible
    - SMPTE VC-2, VC-5, JPEG 2000, AVC, HEVC
  - What compression ratio is needed (3-20x)?
  - Low delay and multi-generation capable
    - Intra frame only

- And other issues as well

Via Satellite: DVB S2X

- DVB-S2 Extensions expected to be standardized September 2013
- Silicon chips available shortly afterwards
  - System replacements possible by mid-2014
- Better efficiency, higher bitrates, improved service robustness
  - Increased granularity in modulation and coding (MODCODs), 87 vs. 28 in DVB-S2
  - Tighter roll-offs
  - Linear and non-linear MODCODs
  - Higher modulation schemes, up to 64APSK
  - Advanced filtering for improved carrier spacing
  - Wideband support up to 72 Mbaud
- No fundamental change to complexity and structure of DVB-S2
- Expected performance is 20-35% efficiency gain vs. DVB-S2

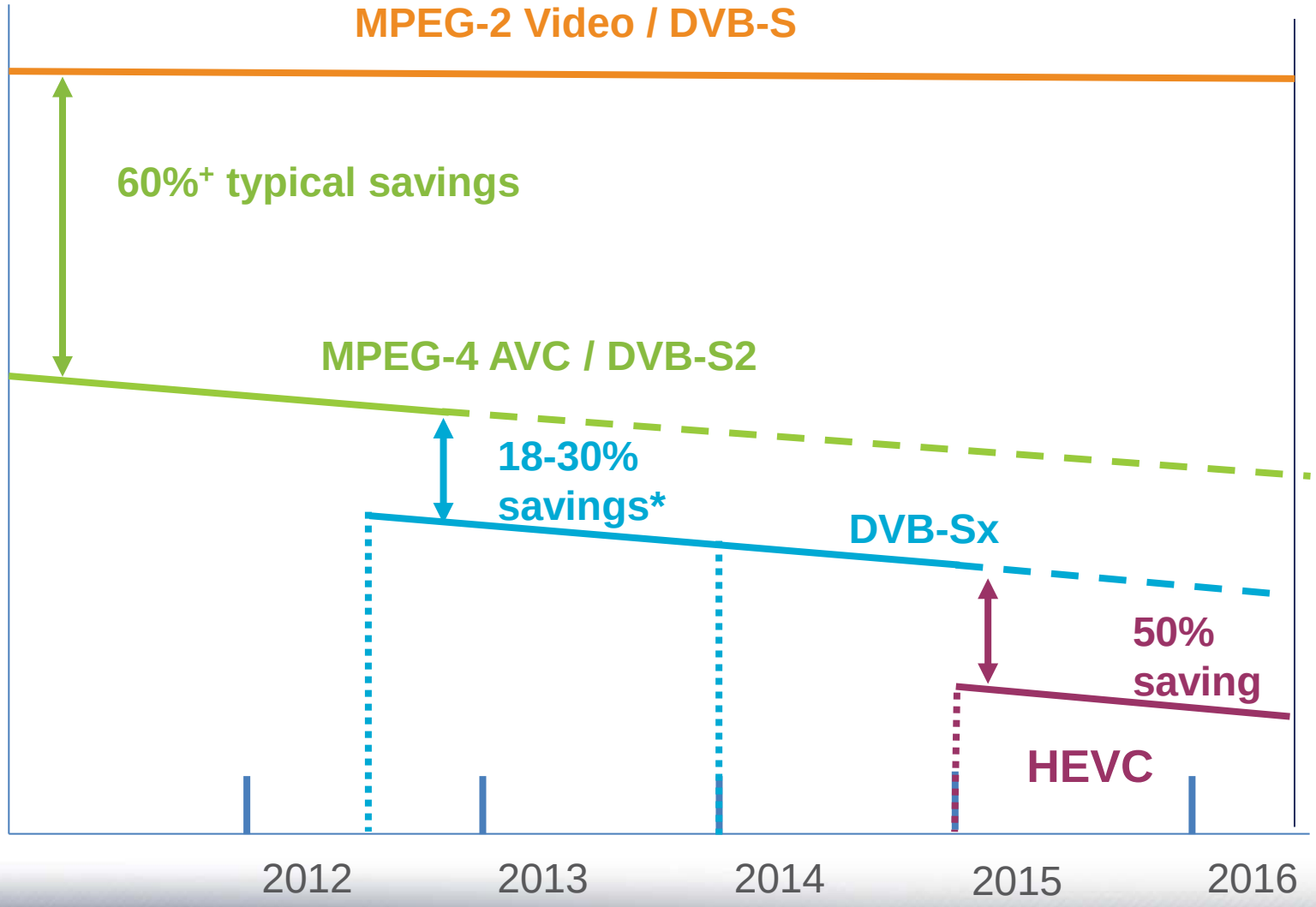
Areas of Gain



Performance examples

- 36MHz, 16APSK 4/5, 10% roll-off: 101 Mbps
- 36MHz, 16APSK 150/180, 5% roll-off: 138 Mbps

Deployment Timeline



Via Fiber

- 100Mbps+ common
- Need Service Level Agreement for transport of high quality real-time video, whether uncompressed or compressed
- SMPTE 2022 Standard family
  - ST 2022-1 *Forward Error Correction for Real-Time Video/Audio Transport Over IP Networks*
  - ST 2022-2 *Unidirectional Transport of Constant Bit Rate MPEG-2 Transport Streams on IP Networks*
  - ST 2022-3 *Unidirectional Transport of Variable Bit Rate MPEG-2 Transport Streams on IP Networks*
  - ST 2022-4 *Unidirectional Transport of Non-Piecewise Constant Variable Bit Rate MPEG-2 Streams on IP Networks*
  - ST 2022-5 *Forward Error Correction for High Bit Rate Media Transport over IP Networks*
  - ST 2022-6 *High Bit Rate Media Transport over IP Networks*

Video Compression Evolution

- High Efficiency Video Coding (HEVC):
  A new standardized compression algorithm
  - An evolution of AVC (H.264 | MPEG-4 Part 10)

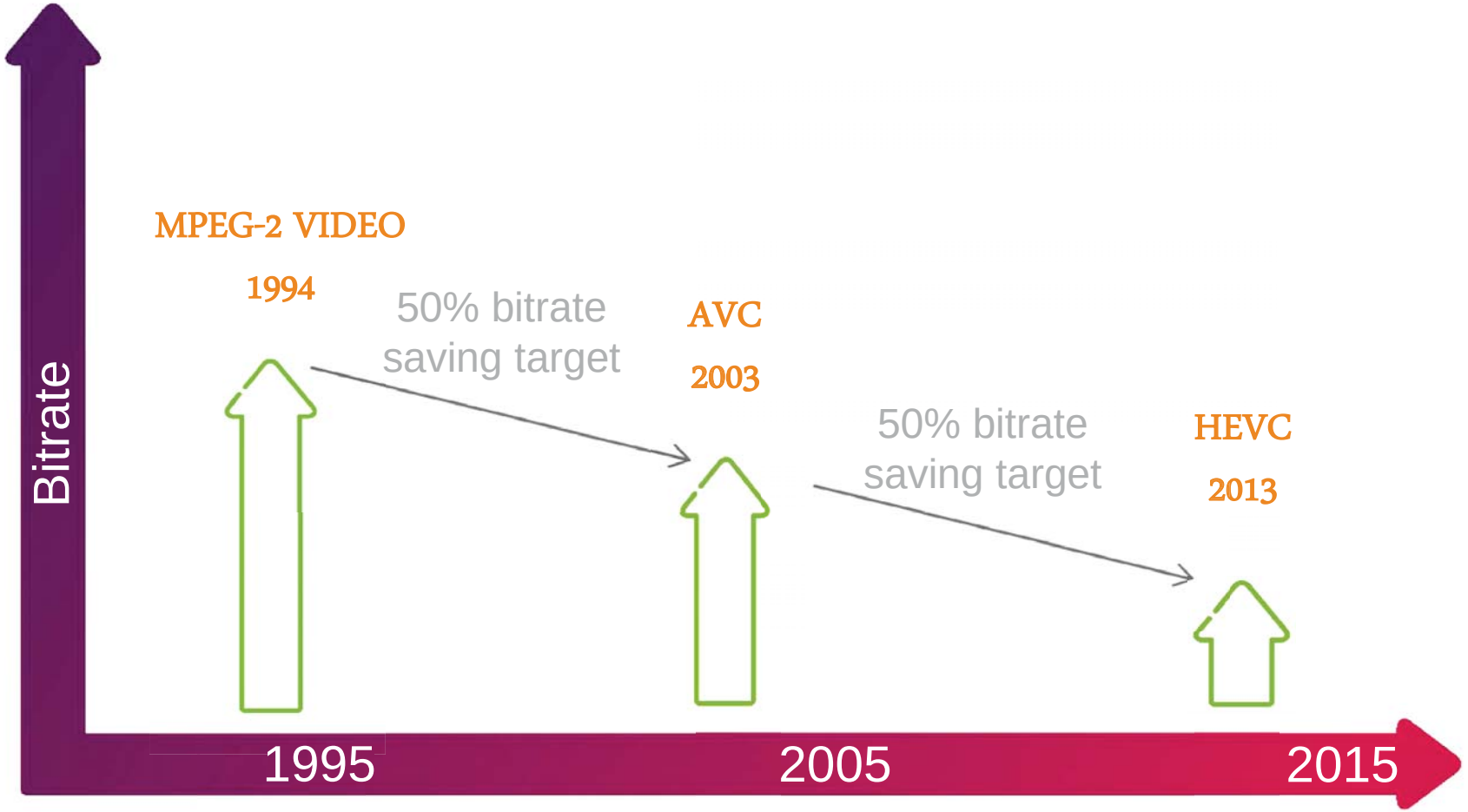
- A **Joint Collaborative Team on Video Coding** (JCT-VC) of MPEG & VCEG

- Aim: To deliver same picture quality for half the bitrate of AVC
  - Up to **10x more computational complexity to encode** and **2x-3x to decode**

- Nomenclature: **ISO/IEC 23008-2 MPEG-H Part 2** and **ITU-T Rec. H.265**

Video Compression Evolution

MPEG-2 Video to HEVC



HEVC Potential - Direct-to-Home

For Similar Picture Quality

	MPEG-2 Video	AVC	HEVC
SD	3 - 5 Mbps	1.5 - 2.5 Mbps	0.8 - 1.5 Mbps
HD	12 - 18 Mbps	6 - 9 Mbps	3 - 4.5 Mbps
4K UHDTV (2160p60 10b)	N/A	16 – 30 Mbps (theory)	8 – 15 Mbps*

Fits in existing channel bandwidth of currently deployed HD!

HEVC Potential - Contribution

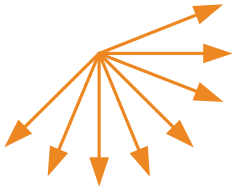
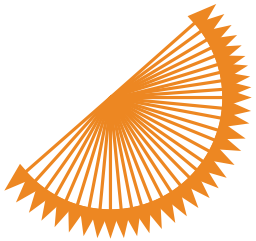
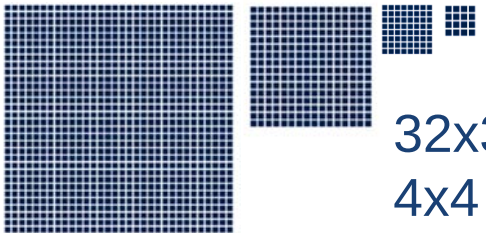
For Similar Picture Quality

	MPEG-2 Video 4:2:2 8b	AVC 4:2:2 10b	HEVC 4:2:2 10b
HD	35 - 60 Mbps	20 - 40 Mbps	14 - 28 Mbps**
4K UHDTV (2160p60)	N/A	100 - 200 Mbps*	50 - 100 Mbps**

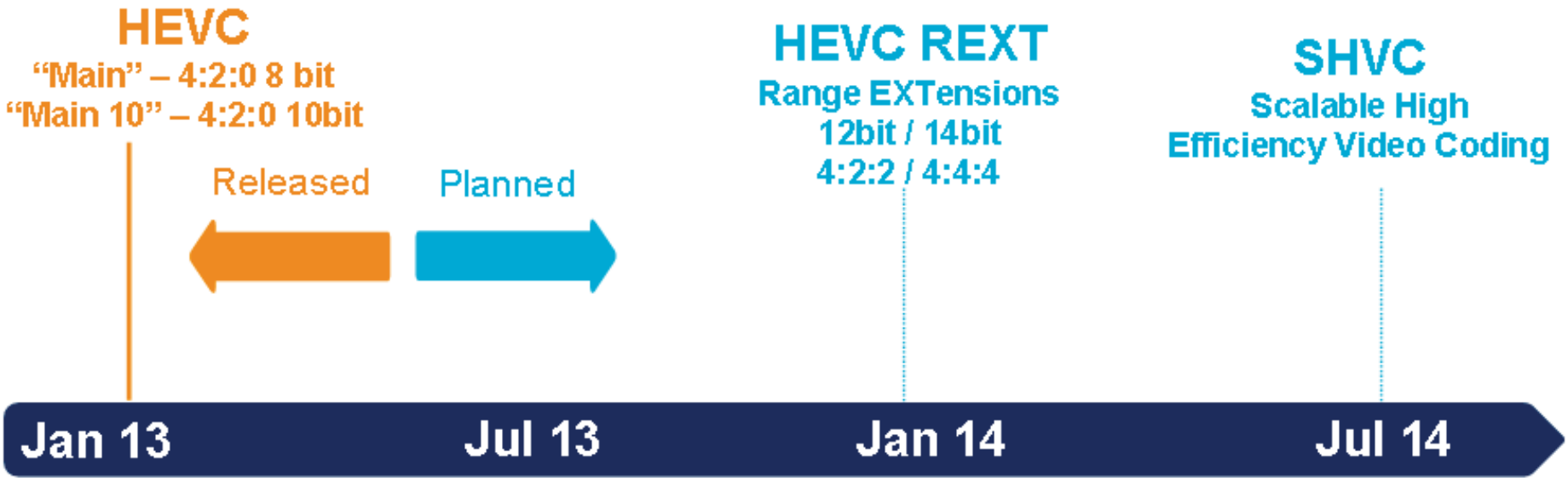
**4 x 1080p60*

***Estimated; HEVC Range Extension profiles not yet standardized*

HEVC – 10x More Complex than AVC

AVC		HEVC	
16X16 block size			64x64 block size
Various Inter partitions down to 4x4			Hierarchical quad-tree partitioning down to 8x8 + 4x4 Transform Units
9 intra modes			35 intra modes
8x8 and 4x4 transform sizes			32x32, 16x16, 8x8 and 4x4 transform sizes

HEVC Development Timelines



Decoder Timescales

- **Broadcast profiles now released**

- **Software decoders – 2013**
  - Multi-core ARM processors
  - Smartphones, Tablets, Smart TVs products announced for 2013 release
- **Hardware decoders - end 2013 / mid 2014**
  - STBs estimated mid-end 2014

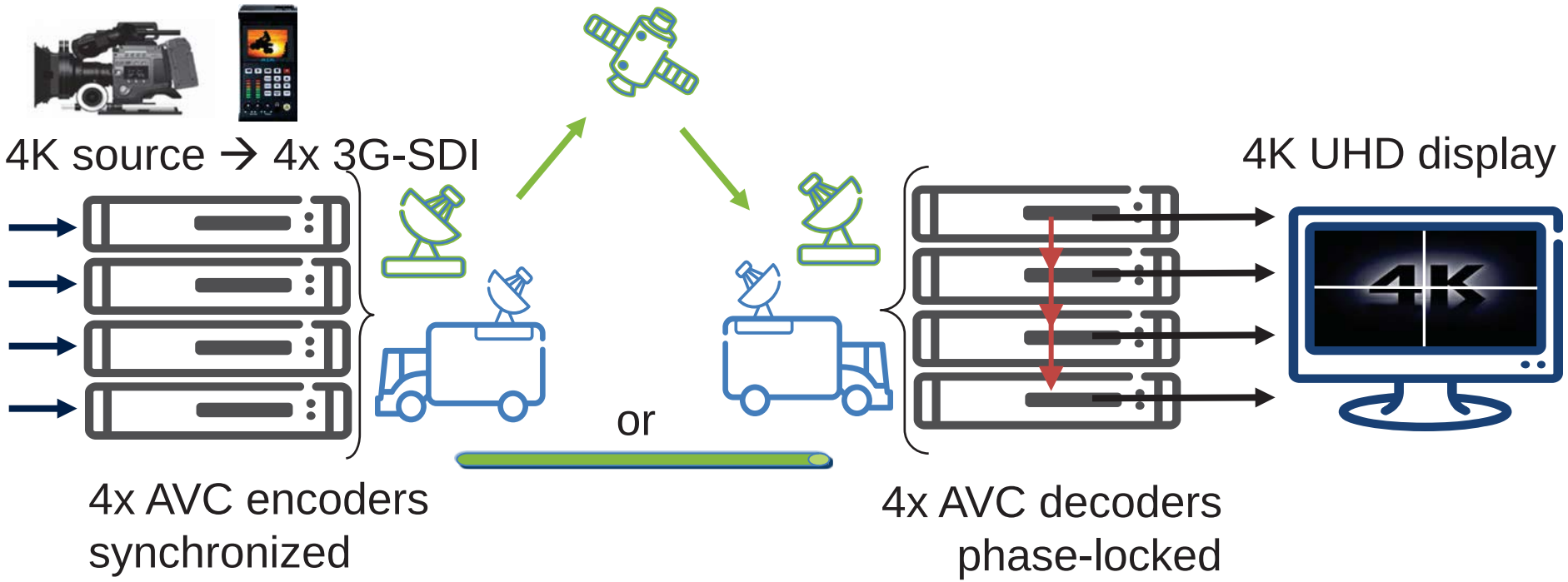
On What format Will Industry Settle for 4K UHDTV?

4K HEVC requires up to 80x more processing power vs. HD AVC

SDTV HDTV 4KTV p24 8b 4:2:0 4KTV p60+ 10b

Note: the audio delivery format for UHDTV is still under discussion

Until HEVC is Ready … 4K Ultra HD Contribution using AVC



Summary

- "Will 4K UHDTV's adoption be more like 3DTV or HDTV?"
  - Depends on how we in the industry present it!
  - ***Can be transformative if the experience is immersive***

- Not all 4K UHDTV solutions are "full" or "true" Ultra HD
  - For an immersive experience,
    - 50-60 fps required for sports and other complex motion content
    - 10-bit depth data values required for all content

- Enabling the acquisition & delivery of compelling UHDTV
  - Still some interface work required to simplify the ecosystem
    - Multi-link 3G-SDI → single link HBR SDI
  - New satellite modulation (DVB-S2 Extensions), fiber QoS (SMPTE 2022 family) and video compression (HEVC)
  - Live AVC-based Contribution ecosystem will jumpstart premium UHDTV service
    - HEVC Range Extensions (4:2:2) still in development

Society of Cable Telecommunications Engineers

30TH ANNIVERSARY

SCTE CABLE-TEC EXPO '13

OCTOBER 21-24 / ATLANTA, GA

Matthew Goldman

Senior Vice President, TV Compression Technology

Ericsson

matthew.goldman@ericsson.com

+1-603-472-9270

ERICSSON