A Comparison of JEM and AV1 with HEVC

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Overview

- Coding Tools
- Coding Efficiency
- Complexity

History of Video Codecs

ISO/IEC/ITU-T	1980s	1990s	2000s	2010s	
	H.120 H.261	MPEG-1 MPEG-2/H.262 H.263 MPEG-4 Part 2	AVC (MPEG-4 Part 10/ H.264)	HEVC (MPEG-H Part 2/ H.265)	JEM

Contenders	1980s	1990s	2000s	2010s	
		TrueMotion S/RT/2 Real Video	VC-X Dirac VP3-7 VP8 Real Video	VP9 Daala Thor Real Video	AV1

Comparison of the latest video codecs (JEM/AV1) with HEVC

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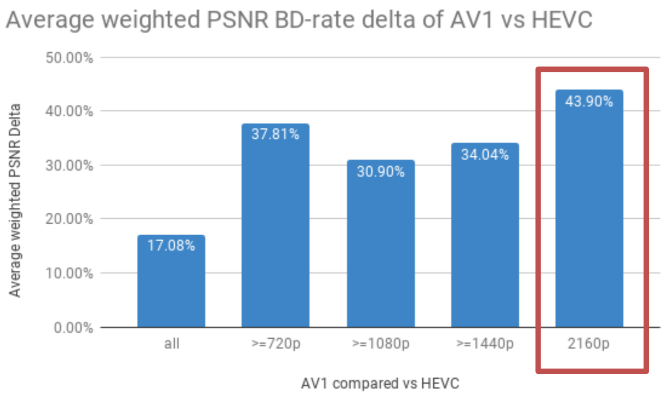
On the Difficulty of Comparing Video Codecs



AV1 is up to 43% better than HEVC

Source: Feldmann, "Multi-Codec DASH Dataset: An Evaluation of AV1, AVC, HEVC and VP9", Bitmovin Blog, 2018

		anchor			
		AV1	**JEM**	**VP9**	**HM**
test candidate	**AV1**		111.8%	-17.1%	47.7%
	JEM	-51.4%		-62.0%	-29.8%
	VP9	21.0%	173.7%		92.5%
	HM	-30.6%	43.4%	-46.6%	

HEVC is 30% better than AV1

Source: Grois et al., "Performance Comparison of AV1, JEM, VP9 and HEVC Encoders", Proceedings of SPIE, 2017

"In terms of PSNR, the average BD-rate savings of AV1 relative to […] x264 high […] are […] 45.8% […]On the other hand, the encoding computational complexity […] was increased by factors of […] 5869.9x"

Source: Liu, "AV1 beats x264 and libvpx-vp9 in practical use cases", Facebook Blog, 2018

Content	AV1 vs HEVC/H.265	
	BD-PSNR	BD-MOS
Campfire Party	-23.2%	-19.0%
Runners	-2.6%	1.5%
Traffic Flow	5.7%	4.9%
Tree Shade	-5.8%	-9.3%
Sintel2	35.6%	38.0%
Average	**1.9%**	**3.2%**

Source: Akyazi and Ebrahimi, "Comparison of compression efficiency between HEVC/H.265 and VP9 based on subjective assessments", QoMEX, 2018

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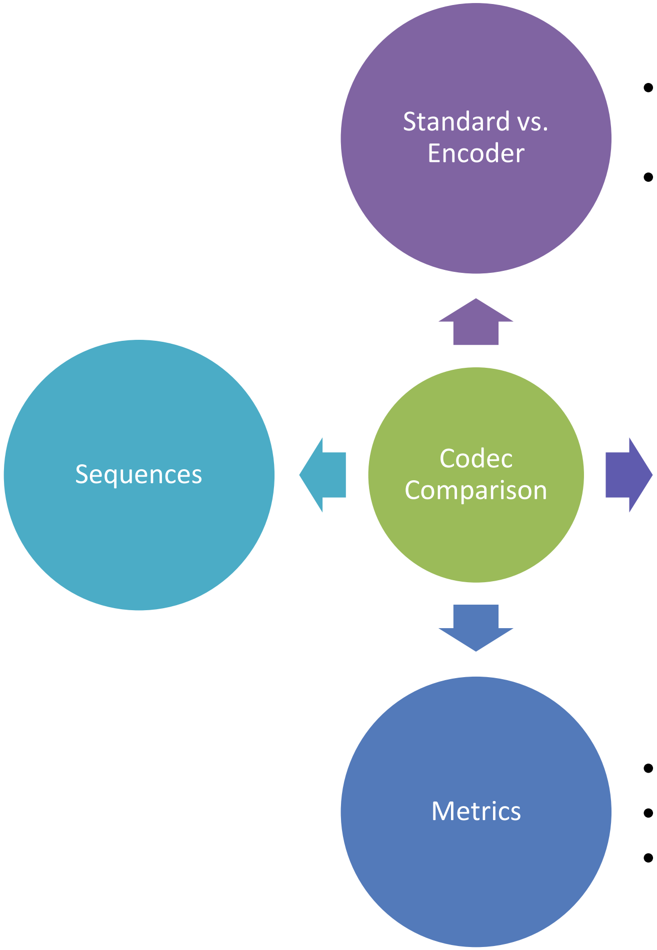

Codecs perform differently good for different content

- Reference implementations (HM/JEM/aomenc)
- Optimized encoders (x264/x265)

- Computing resources
- Applications: e.g. Broadcasting, VoD, Social Media
- Tuning (e.g. PSNR, visual

- Luma BD-rates, weighted BD-rates
- Quality metrics: PSNR, SSIM, VMAF
- Subjective Tests

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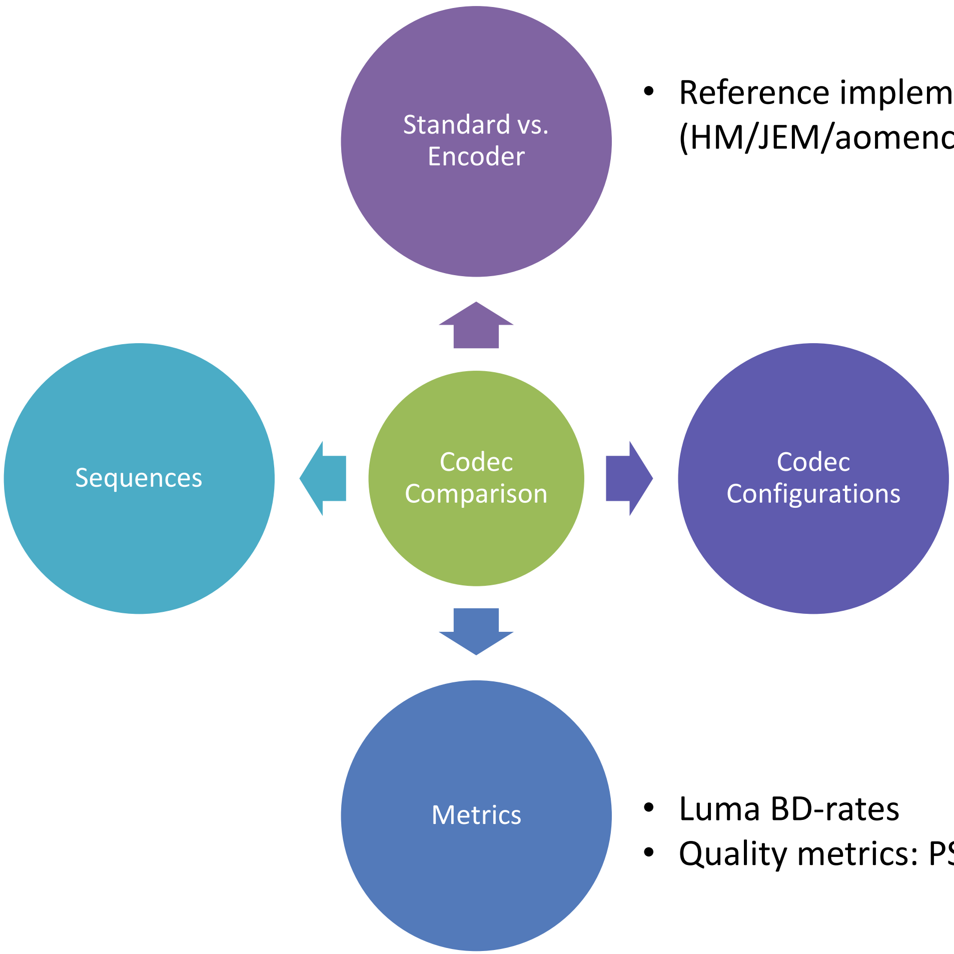
Test Conditions for this Comparison

Class	Sequence
A1 (4K)	Tango2
	Drums100
	Campfire
	ToddlerFountain2
A2 (4K)	CatRobot
	TrafficFlow
	DaylightRoad2
	Rollercoaster2
B (1080p)	Kimono
	ParkScene
	Cactus
	BasketballDrive
	BQTerrace
C (WVGA)	BasketballDrill
	BQMall
	PartyScene
	RaceHorses
D (WQVGA)	BasketballPass
	BQSquare
	BlowingBubbles
	RaceHorses
E (720p)	FourPeople
	Johnny
	KristenAndSara
F (Screen/ Mixed Content)	BasketballDrillText
	ChinaSpeed
	SlideEditing
	SlideShow



- Reference implementations (HM/JEM/aomenc)

- HM/JEM: Common Test Conditions (CTC)
- AV1

```
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```

- Luma BD-rates
- Quality metrics: PSNR

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Coding Tools

JEM

Partitioning
- Quaternary and binary splits
- Bigger block size

Inter coding
- Overlapped block motion compensation
- Higher order motion model
- Sub-CU MV prediction

Intra coding
- Additional directions
- Cross-component linear model

Transform coding
- Adaptive multiple transforms
- Non-separable secondary transform
- Signal-dependent transform

AV1

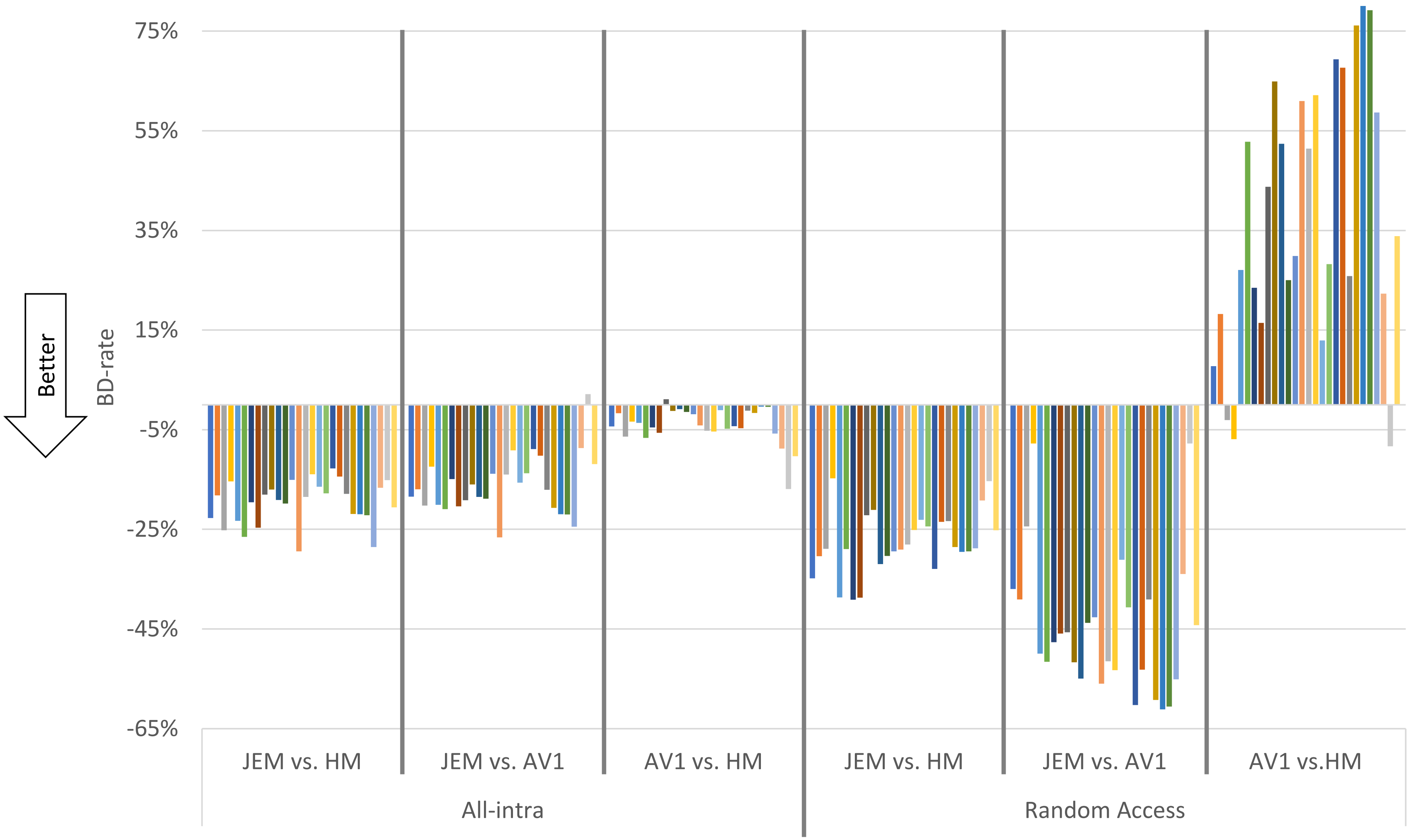
Partitioning
- Quaternary and binary splits
- Bigger block size

Inter coding
- Overlapped block motion compensation
- Higher order motion models
- Wedge mode partitioning
- Compound intra-inter prediction

Intra Coding
- Directional, Paeth, Smooth prediction
- Intra block copy
- Palette mode

Transform coding
- DCT, DST, Identity
- Independent horizontal/vertical transforms

Coding Efficiency



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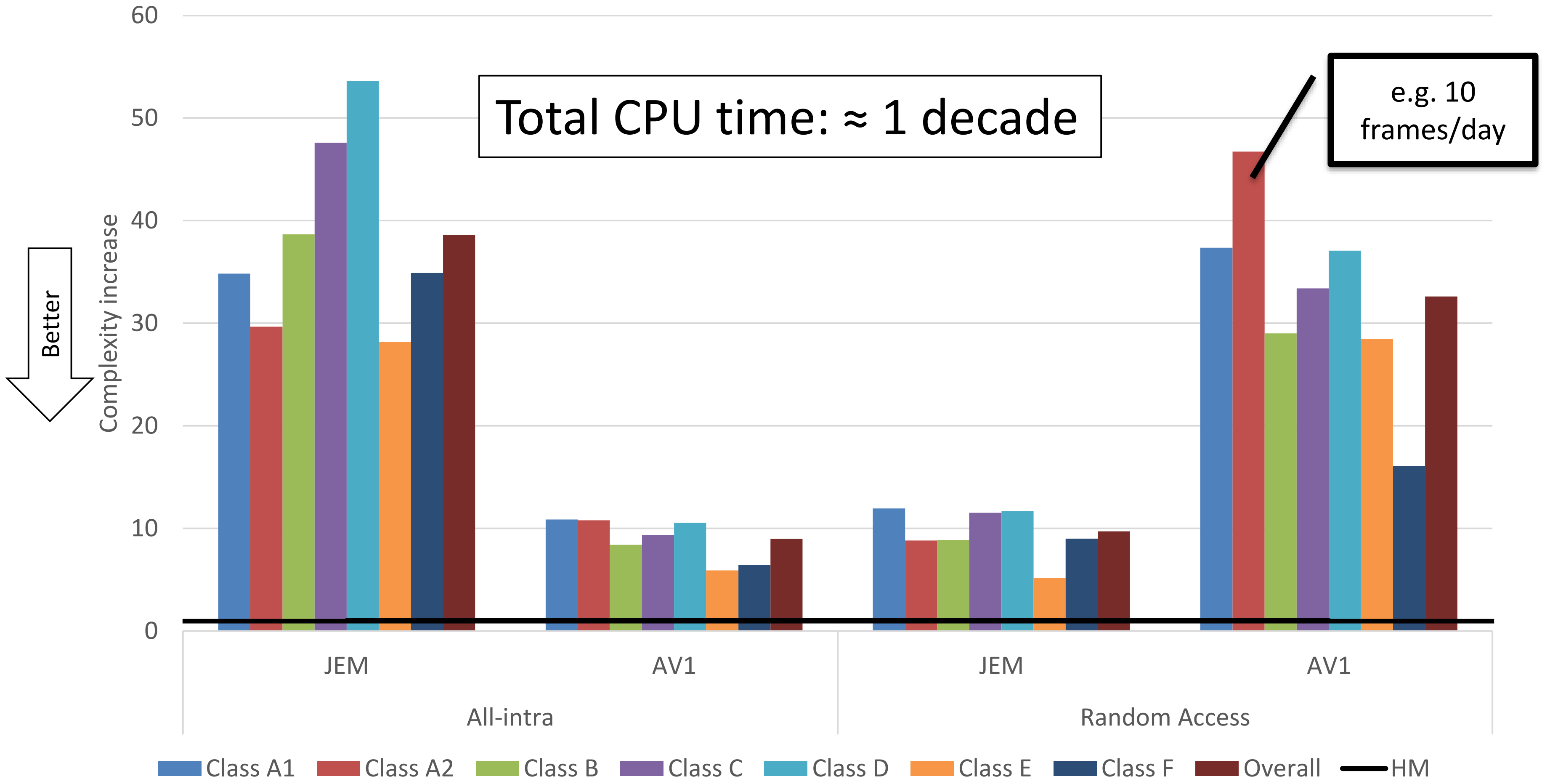
Encoder Runtimes



Relative factors to HM, i.e. HM=1

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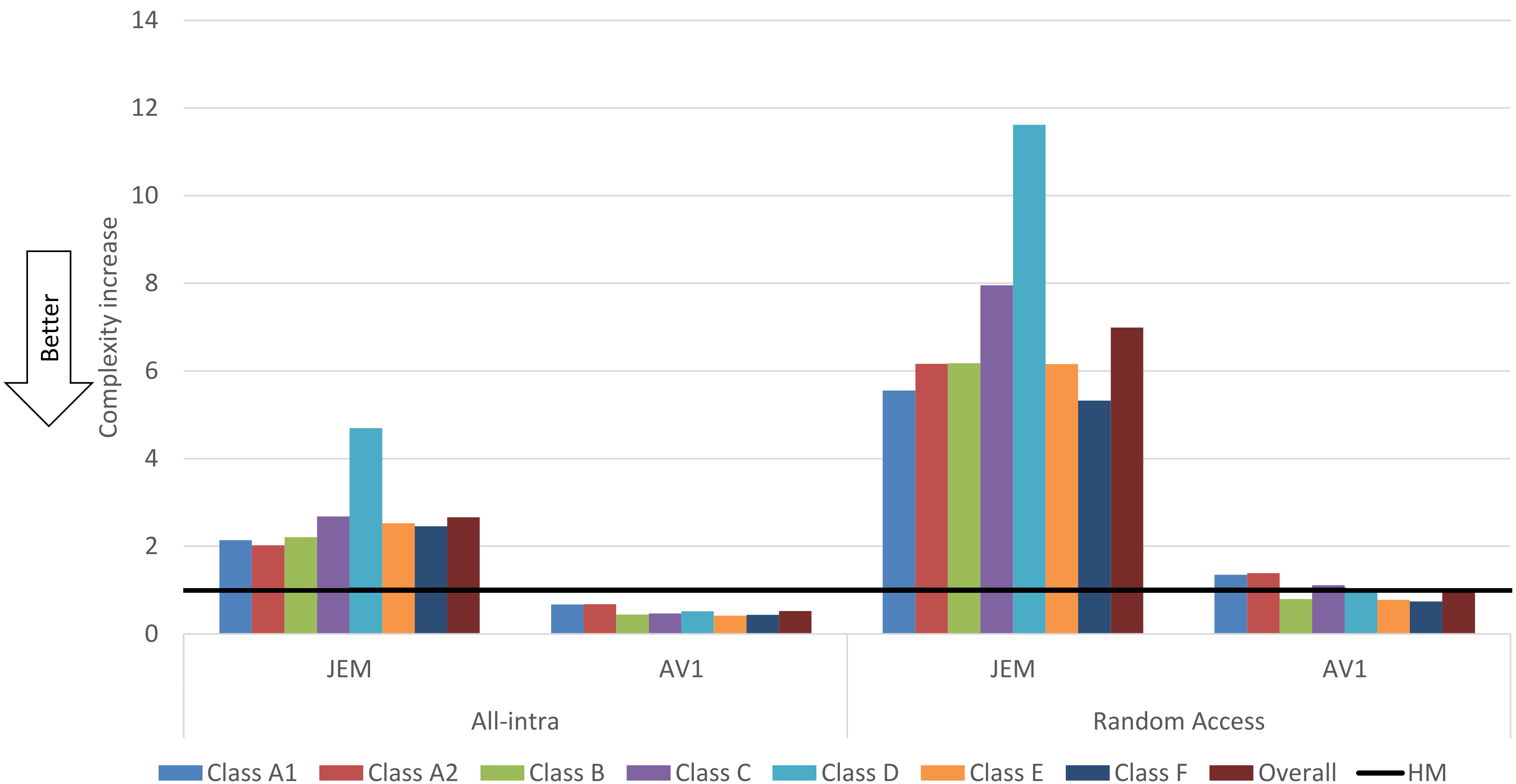
Decoder Runtimes



Relative factors to HM, i.e. HM=1

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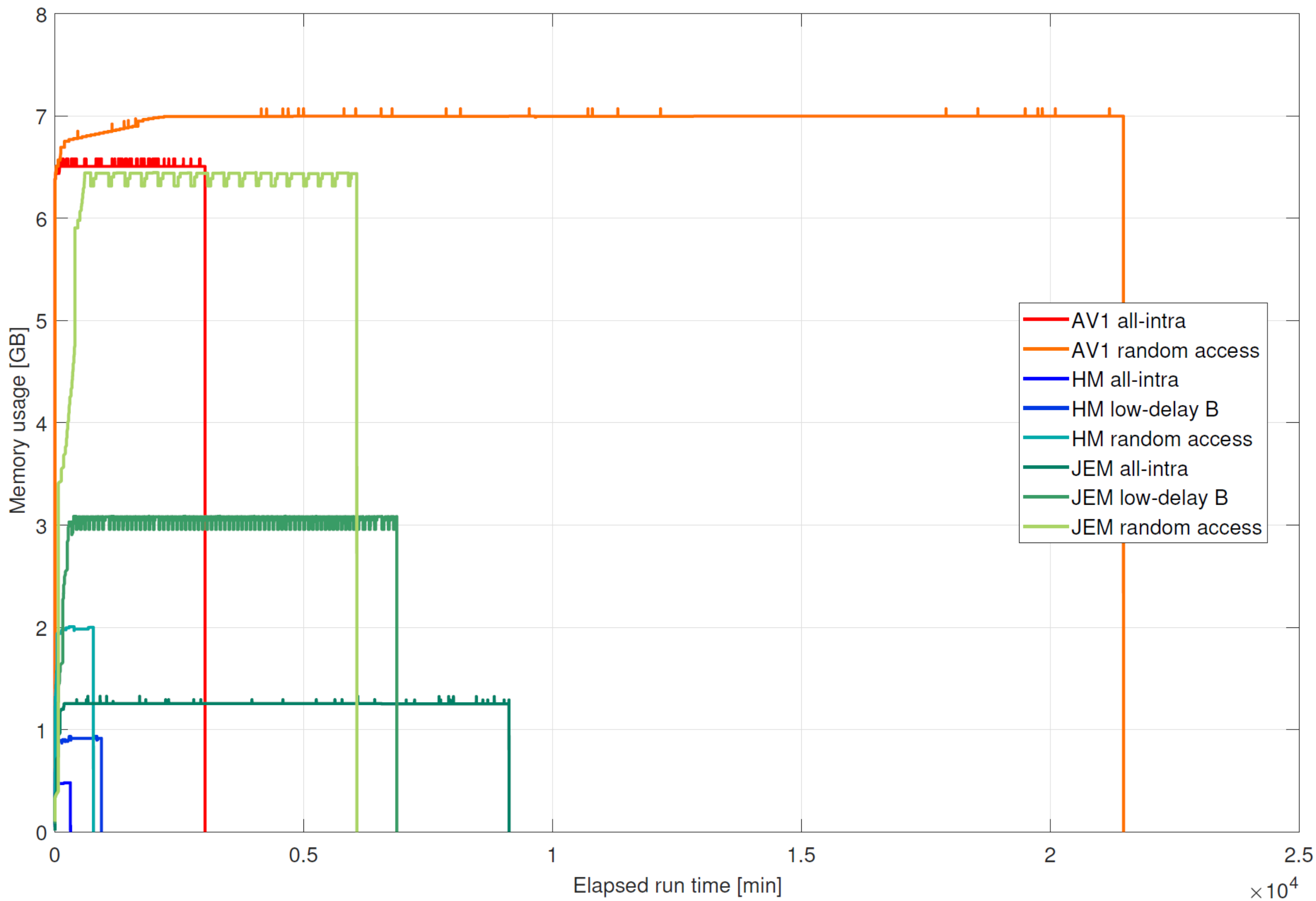
Runtime-memory Complexity



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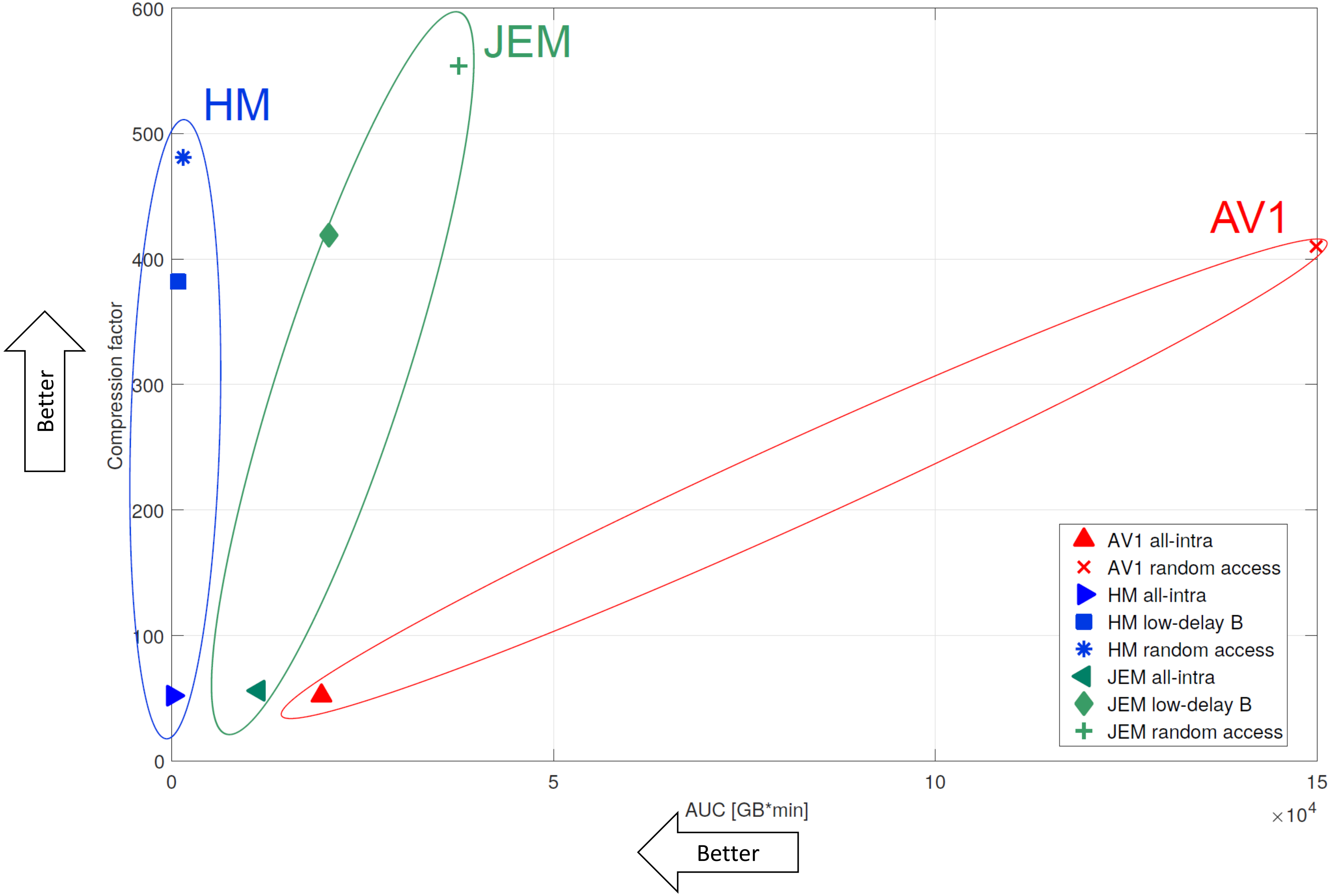
Trade-off Coding Efficiency vs. Complexity



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Summary

Coding Efficiency

Comparison vs. HM

All intra (AI)
JEM: 20% gain
AV1: 4% gain

Random Access (RA)
JEM: 28% gain
AV1: 38% loss

Runtimes

Comparison vs. HM

Encoder
JEM: 39 × (AI)/10 × (RA) slower
AV1: 9 × (AI)/32 × (RA) slower

Decoder
JEM: 3 × (AI)/7 × (RA) slower
AV1: 2 × faster (AI)/same (RA)

Closing remarks

- Results are a snapshot of summer 2017 → AV1 finalization in March 2018 and JVET CfP evaluation in April 2018
  - Since last summer, AV1 has gained additional 5% (based on 80 preliminary data points)
- Complexity: Reference implementations vs. product implementations

Details: Laude, T., Adhisantoso, Y. G., Voges, J., Munderloh, M., & Ostermann, J. (2018). A Comparison of JEM and AV1 with HEVC: Coding Tools , Coding Efficiency and Complexity. In *Picture Coding Symposium (PCS)*.