

COMPARING AV1, V9, HEVC, AND H.264

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Agenda

- Who are the competitors?
- Setting the ground rules
- Results
- Conclusions

What I tested

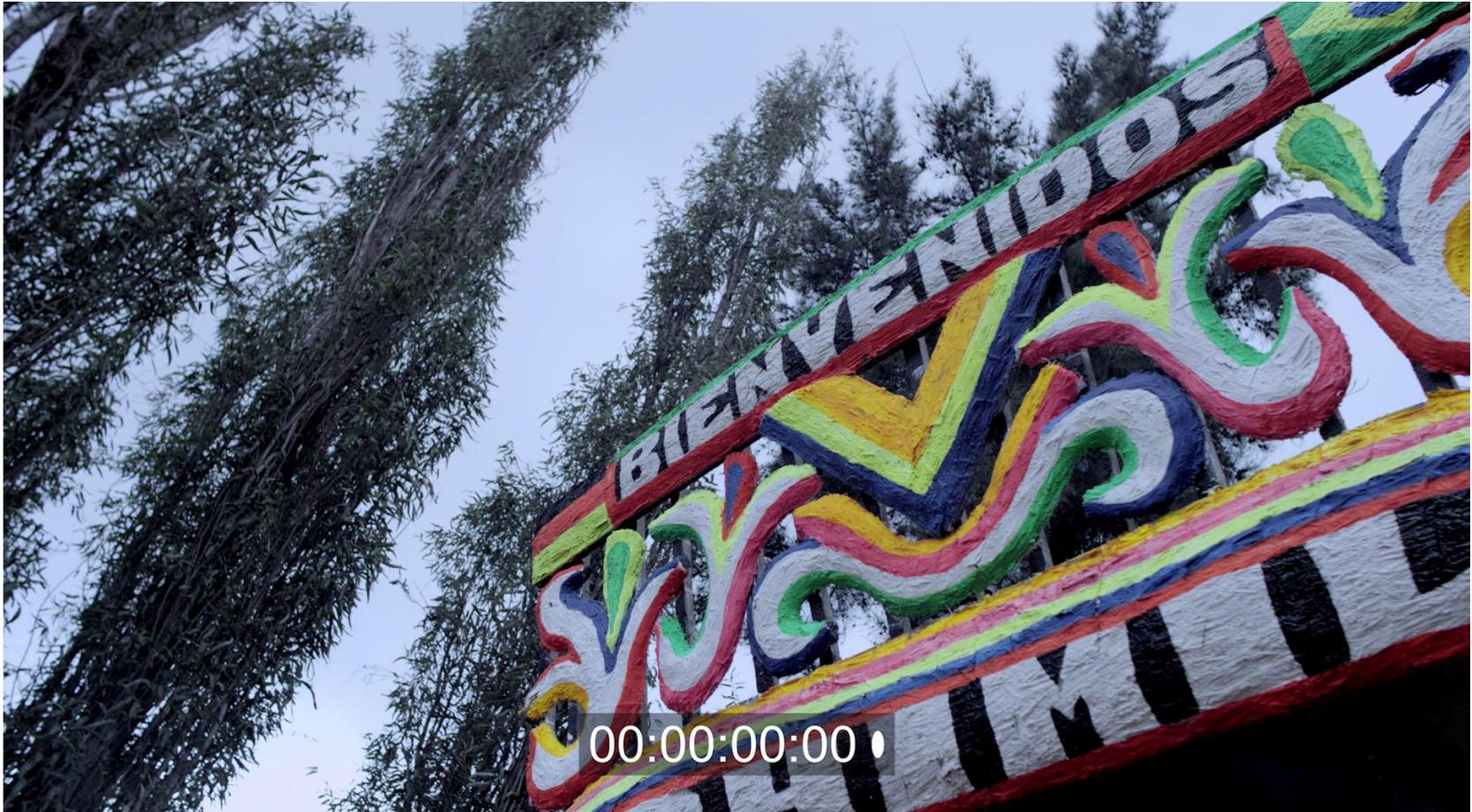
- Codecs

- x264 as baseline
- Main Concept HEVC
- x265
- VP9 (Google)
- AV1 (more later)

- Focus

- VOD
- 720p, 1080p, 4K
 - Six data rates each
- Seven short video files

Boat



Food Market



Fork Lift



Liquor Store



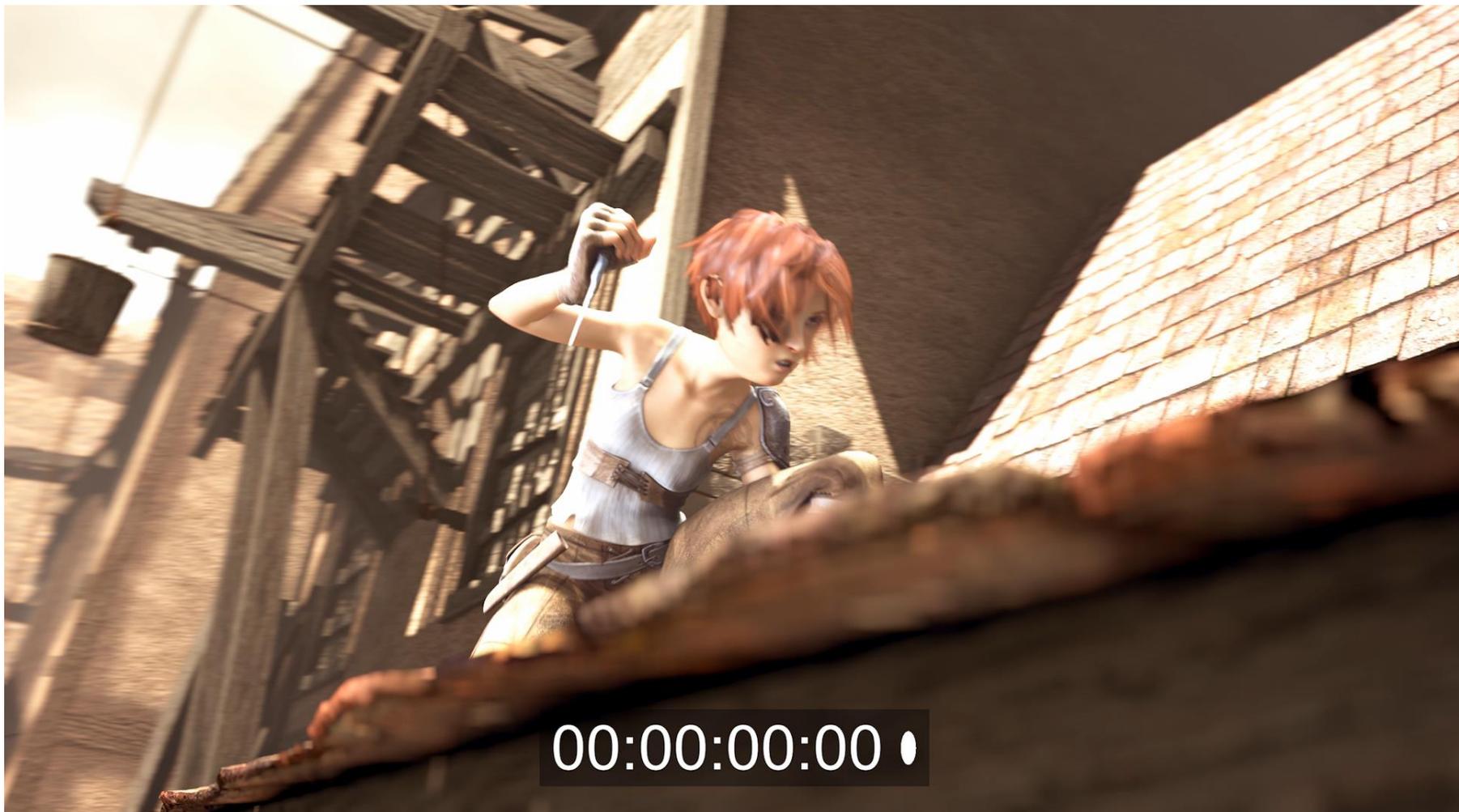
Pier



Ritual Dance



Sintel



File Creation Process

- Downloaded raw file
- Inserted time code
- Output 4K (300 Mbps), 1080p (100 Mbps), and 720 (50 Mbps) versions
- Files to MainConcept, MulticoreWare, and AV1 vendor
- Verified encoding params
- Ran tests with MSU tool

Building the Perfect Codec Comparison

1. Agree on clips/parameters/tests • Done
2. Encode • Done
3. Score encodes (VMAF) • Done
4. Subjectively confirm scores • Not done
5. Compute Bjontegaard metrics • Not done

Status of AV1

- Bitstream schedule to freeze by 12/31
- Expected to be at least 20% higher quality than HEVC upon release (or won't be released)
- AV1: A Status Update - <http://bit.ly/av1-stat>

Big Issue – AV1 Encodes

- Came back worse than previous encodes
 - “We believe there must be a bug somewhere in the way we are using the encoder currently.
 - Probably some settings got changed or some settings are missing, etc.
 - The files we provided can't be right as the quality back some months was already better and there were multiple improvements along the road”
- Oops – so, AV1 included in some comparisons, but definitely not representative
 - Will hope to include and recompute in the next 30 days or so

What's Going to Happen

- Confirm subjective
- Compute BD
- Get updated AV1
- Republish results on Streaming Learning Center (maybe Streaming Media)
- These results preliminary

Basic Encoding Parameters

720p	Width	Height	Data Rate	Bits/pixel (30 fps)	Max DR	VBV	Key-Frame
450 kbps	1280	720	450	0.0163	495	450	2
675 kbps	1280	720	675	0.0244	742.5	675	2
1 Mbps	1280	720	1000	0.0362	1100	1000	2
1.5 Mbps	1280	720	1500	0.0543	1650	1500	2
2.2 mbps	1280	720	2200	0.0796	2420	2200	2
3 Mbsp	1280	720	3000	0.1085	3300	3000	2
1080p							
1 mbps	1920	1080	1000	0.0161	1100	1000	2
1.5 mbps	1920	1080	1500	0.0241	1650	1500	2
2.2 mbps	1920	1080	2200	0.0354	2420	2200	2
3 Mbps	1920	1080	3000	0.0482	3300	3000	2
4.5 mbps	1920	1080	4500	0.0723	4950	4500	2
6.7 mbps	1920	1080	6700	0.1077	7370	6700	2
4K							
3 mbps	3840	2160	3000	0.0121	3300	3000	2
4.5 mbps	3840	2160	4500	0.0181	4950	4500	2
6.7 mbps	3840	2160	6700	0.0269	7370	6700	2
10 mbps	3840	2160	10000	0.0402	11000	10000	2
15 mbps	3840	2160	15000	0.0603	16500	15000	2
22 mbps	3840	2160	22000	0.0884	24200	22000	2

Choosing the Quality Setting

- X265
 - Tried to find reasonable setting where MC/x265 performed similarly
 - Tested on Intel Core i7 7700K, which is a 4-core/8-threads machine
 - Slow preset for x265
 - Setting of 28 for MainConcept
 - Both vendors encoded their own files and supplied command scripts to me to confirm
- AV1 comparisons
 - Both HEVC encoders encoded at highest quality to compare with AV1 – didn't use because AV1 quality was hosed
- VP9/H.265 – encoded with highest quality “reasonable” preset (very slow/4/1)

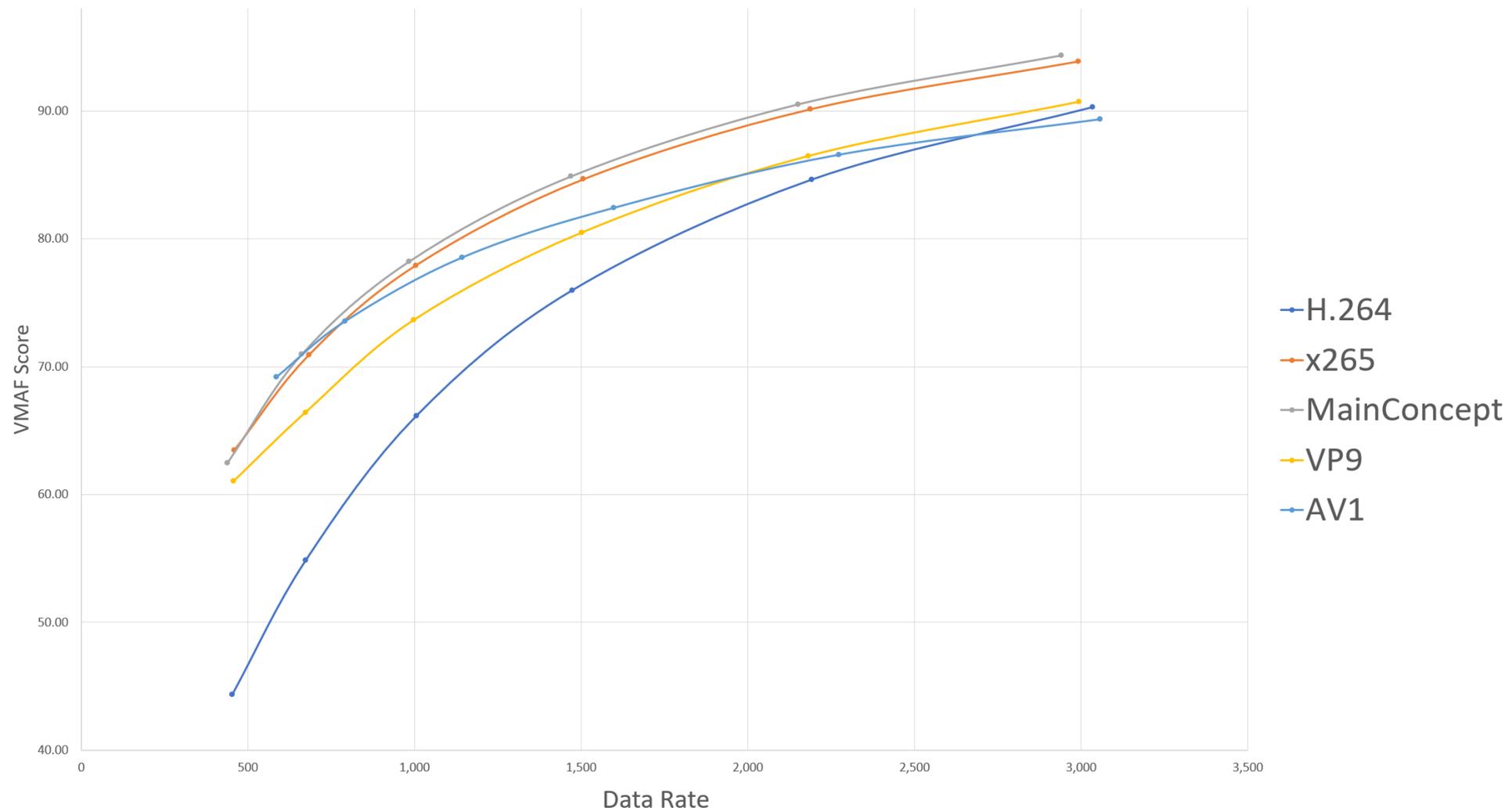
Measured Quality with VMAF

- Video Multimethod Assessment Fusion (VMAF)
 - Objective metric used by Netflix in their per-title optimization workflow
 - Replaced PSNR
 - Open source
 - Meld of four basic benchmarks
 - Scales from 0 – 100
 - Higher scores better
 - Differential of 6 is JND
- Used Moscow State University VQMT tool to compute

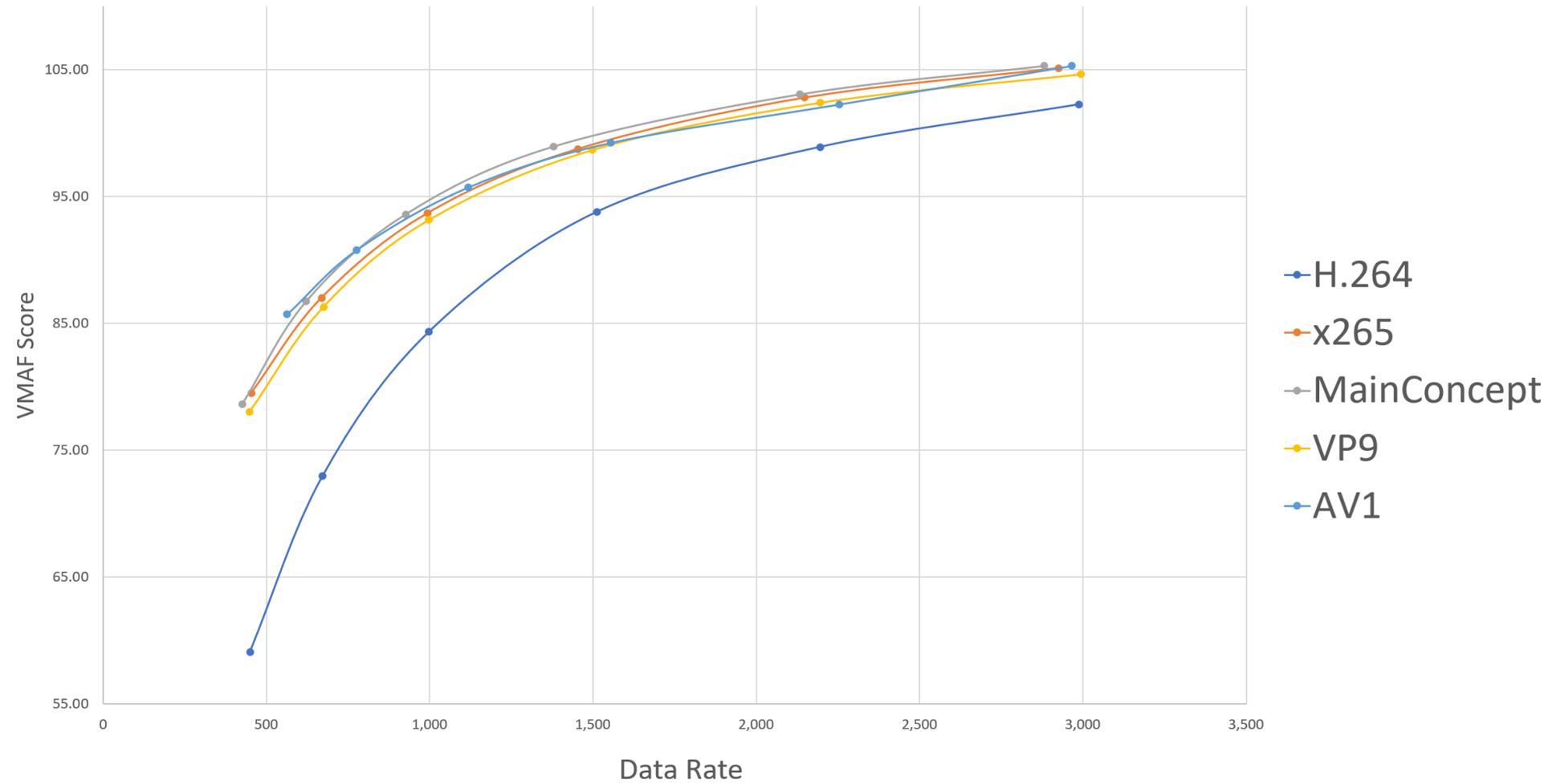
Results

- 720p
- 1080p
- 4K

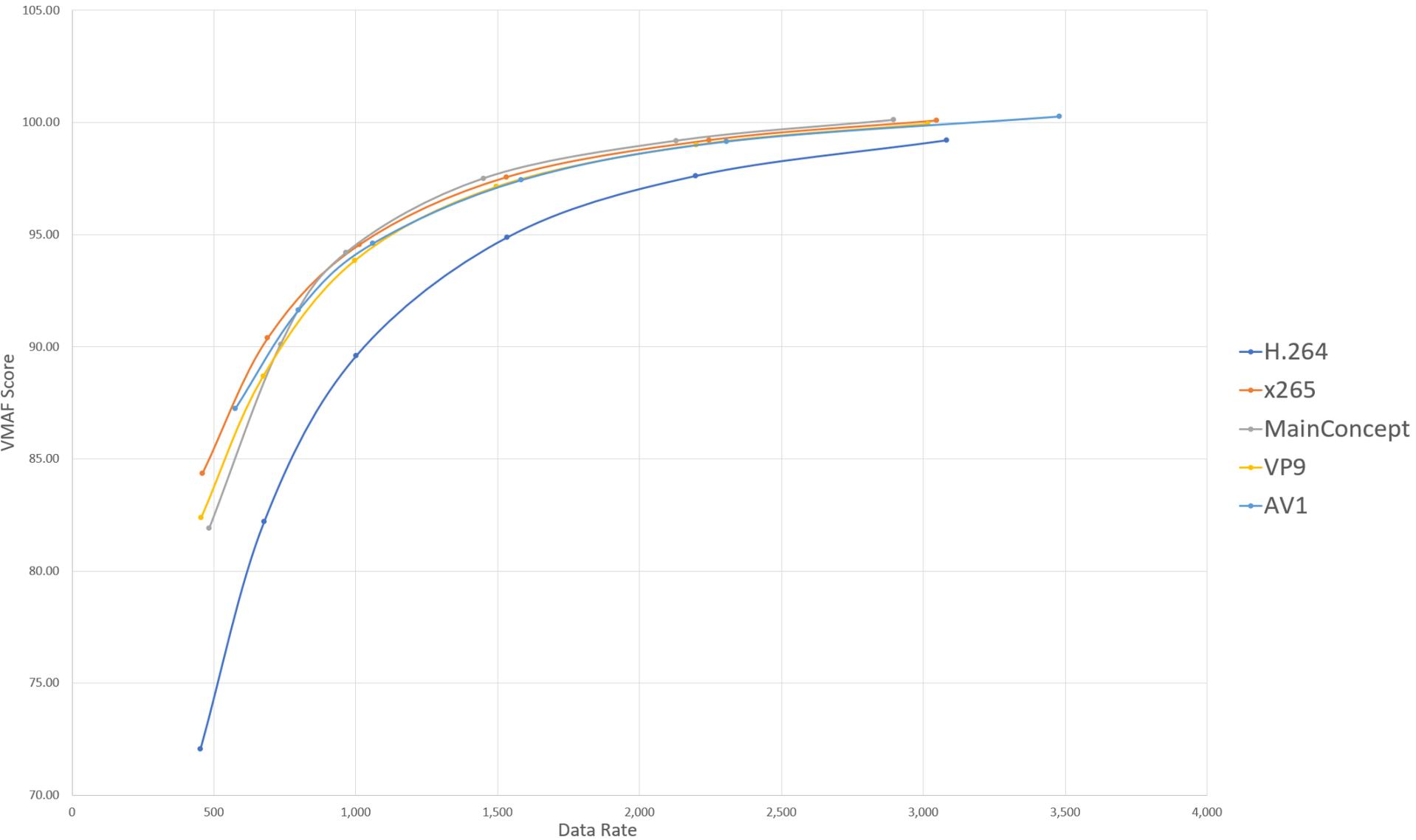
Boat Clip - 720p



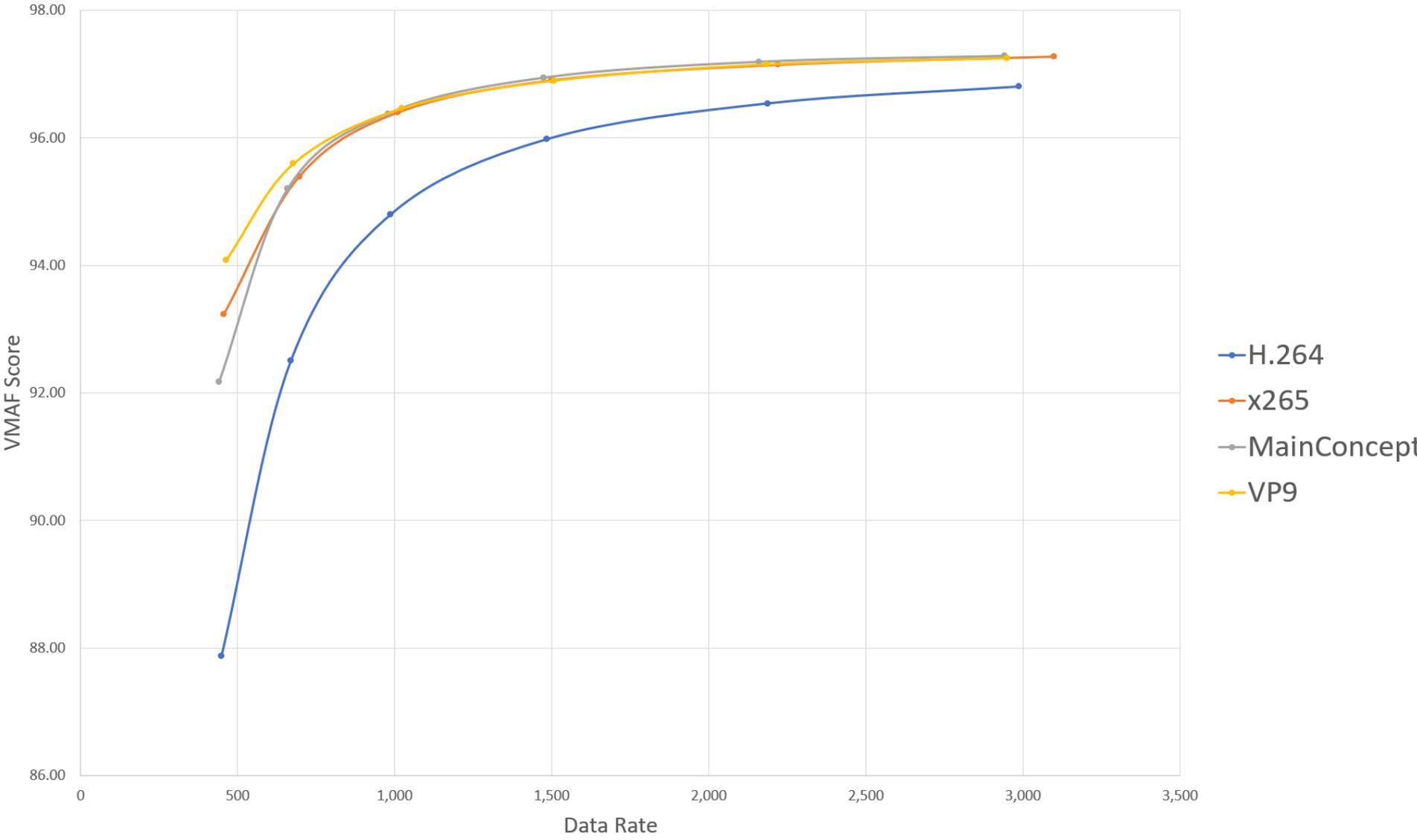
Food Market Clip - 720p



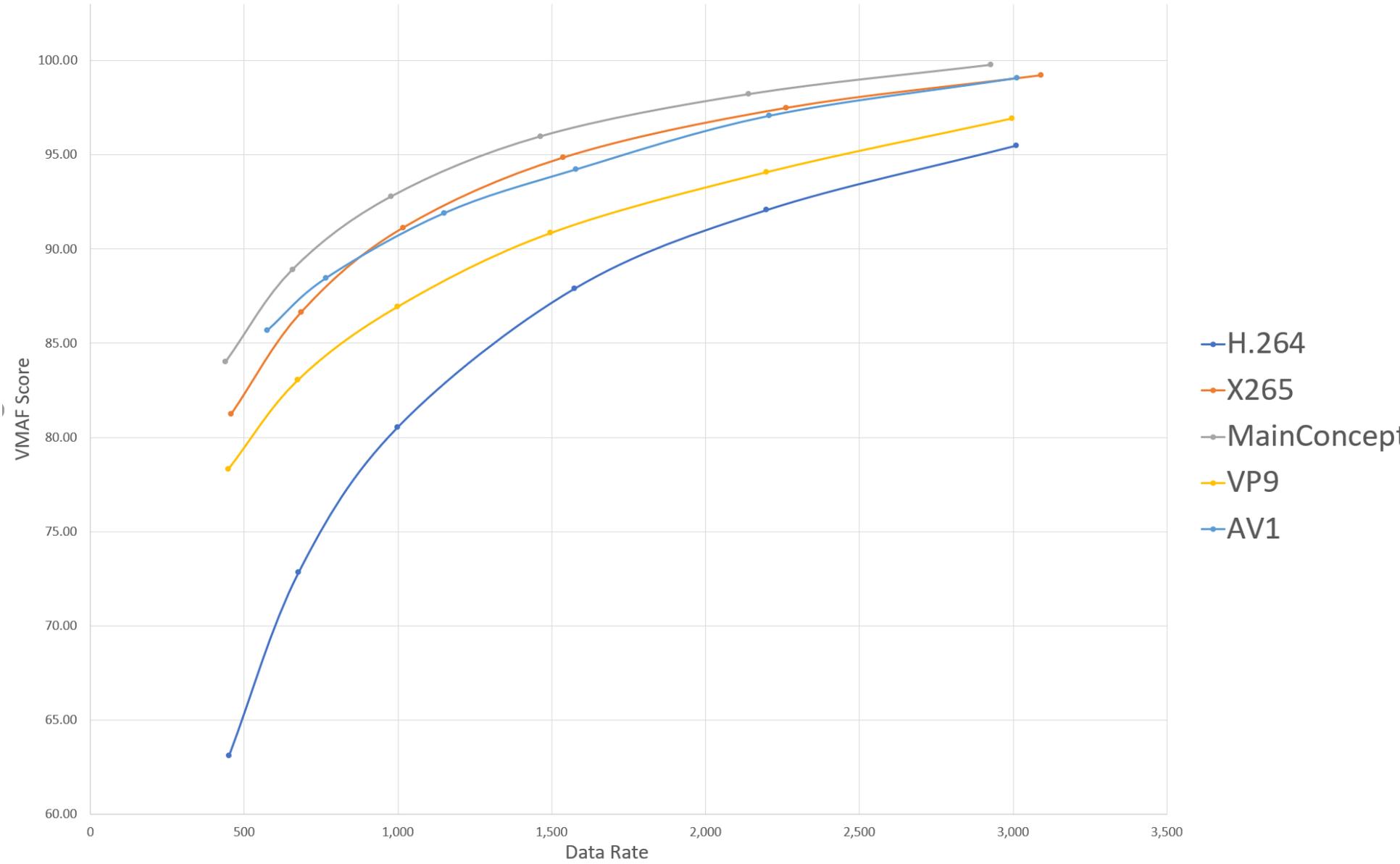
Forklift Clip - 720p



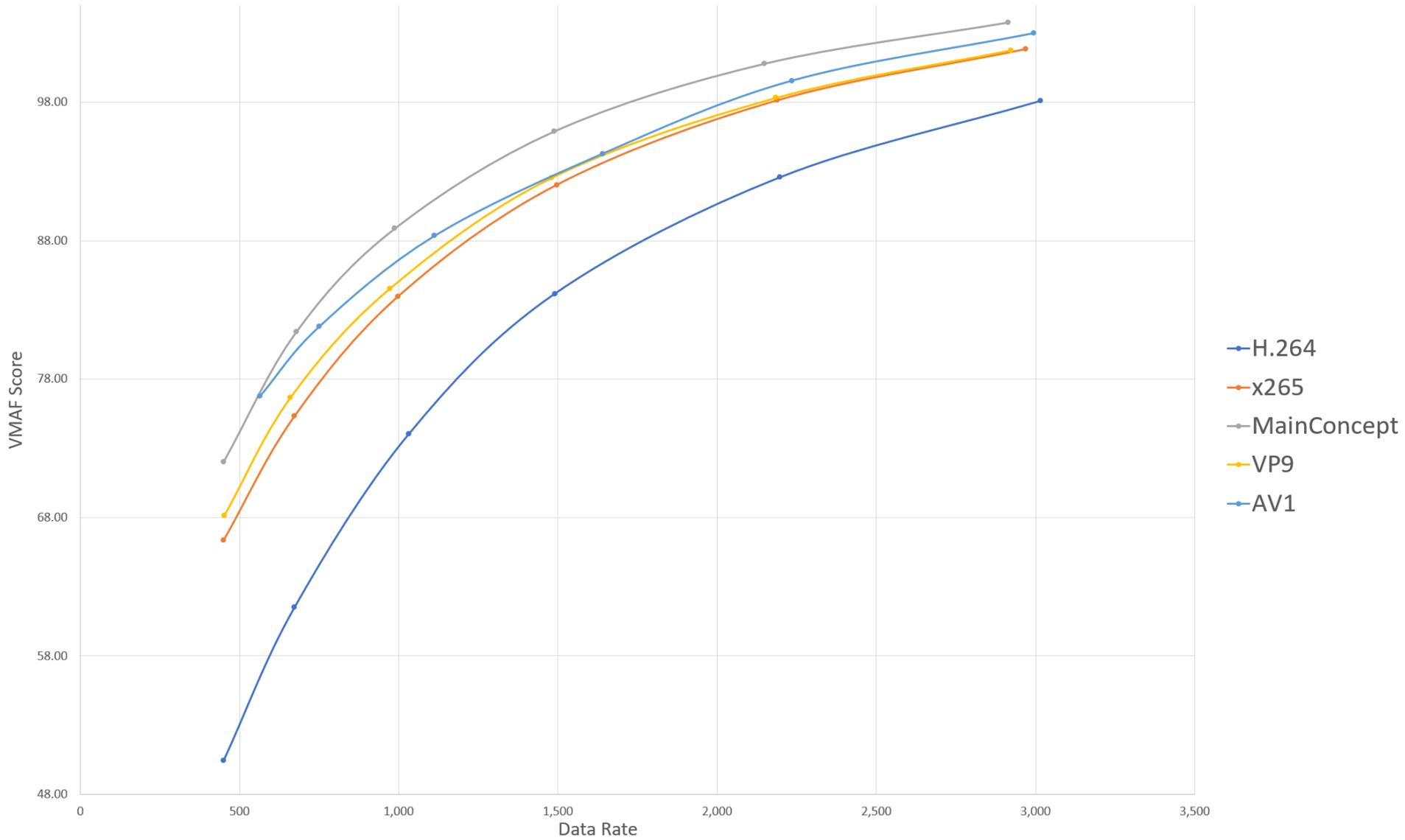
Liquor Store Clip - 720p



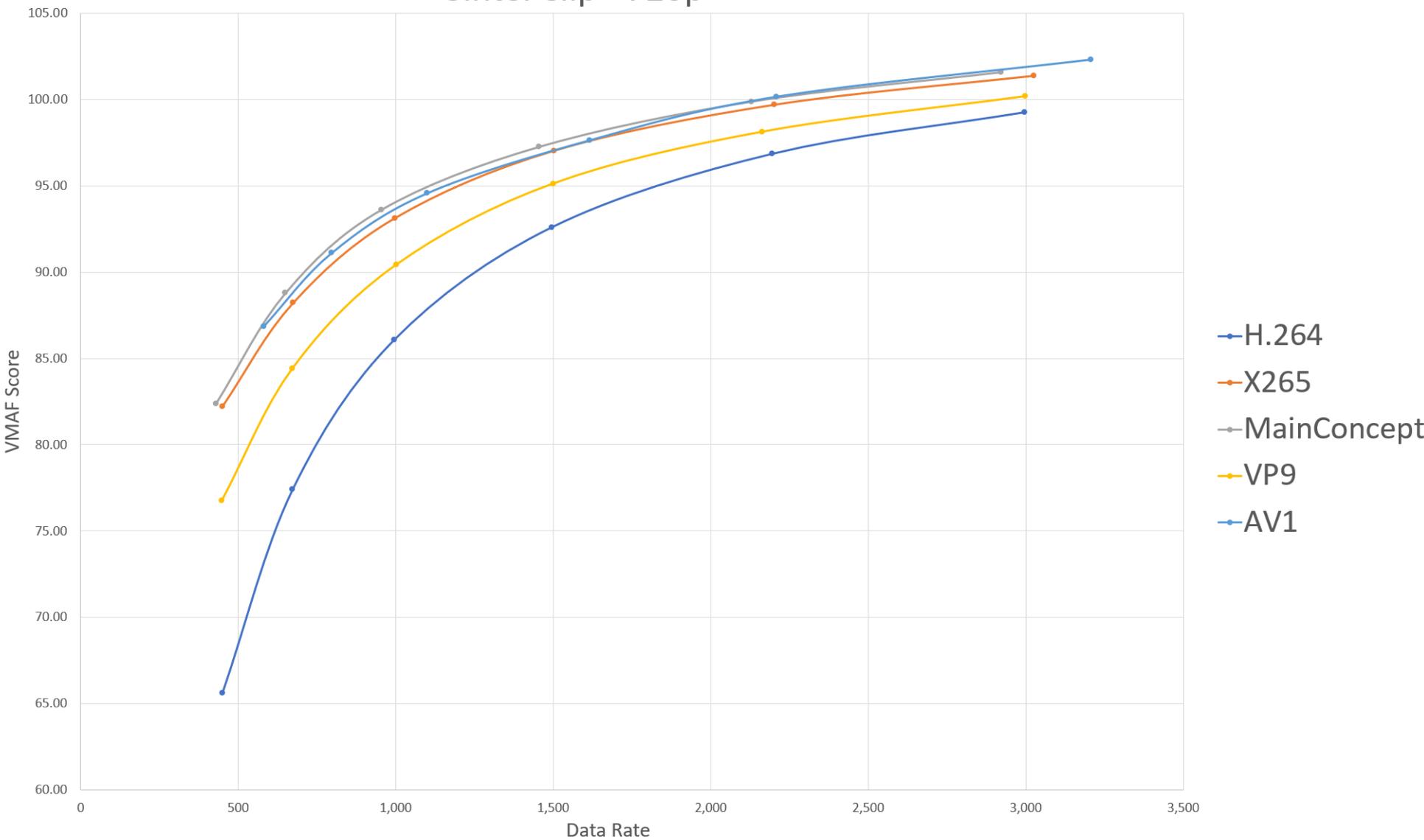
Pier Clip - 720p



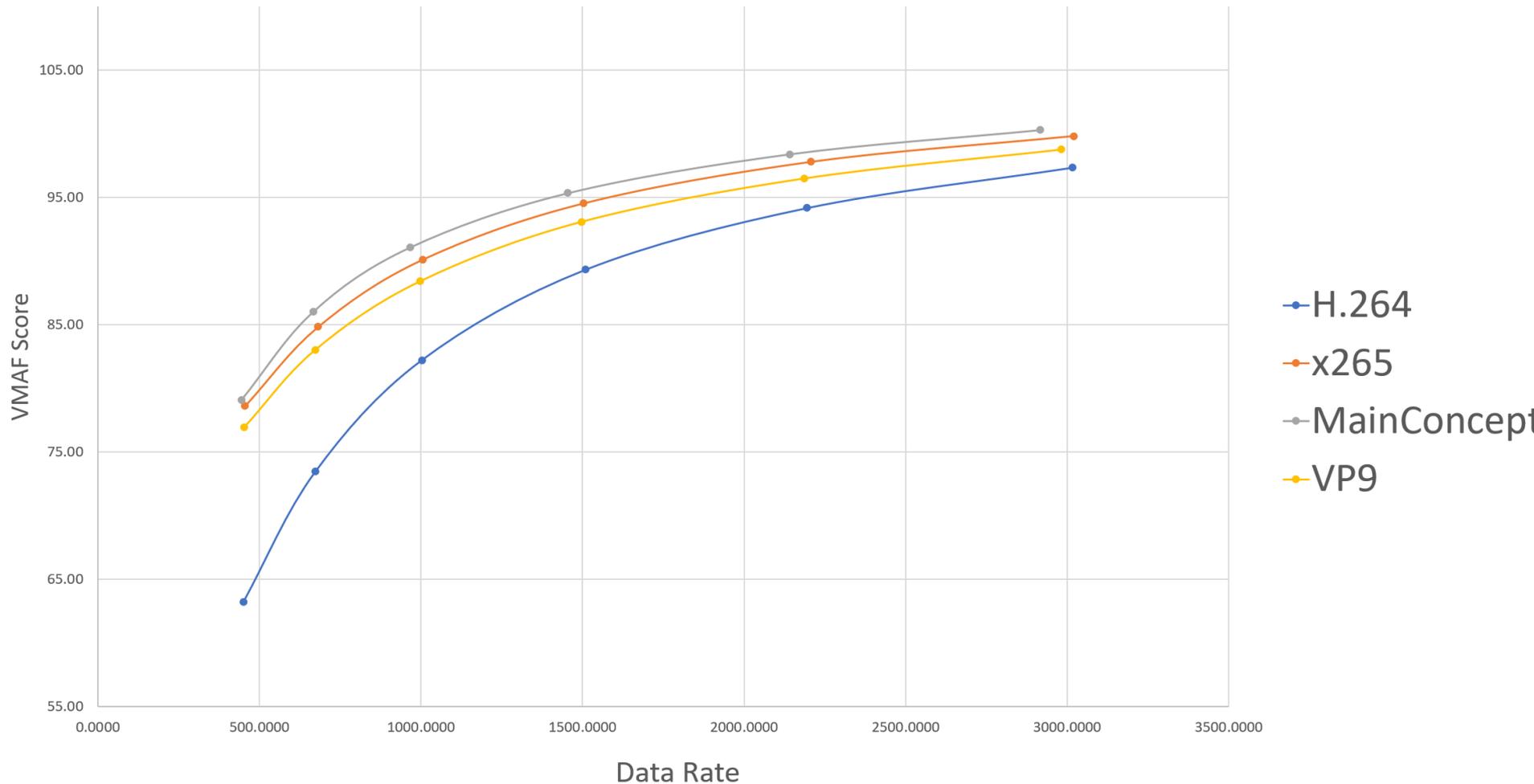
Ritual - 720p



Sintel Clip - 720p

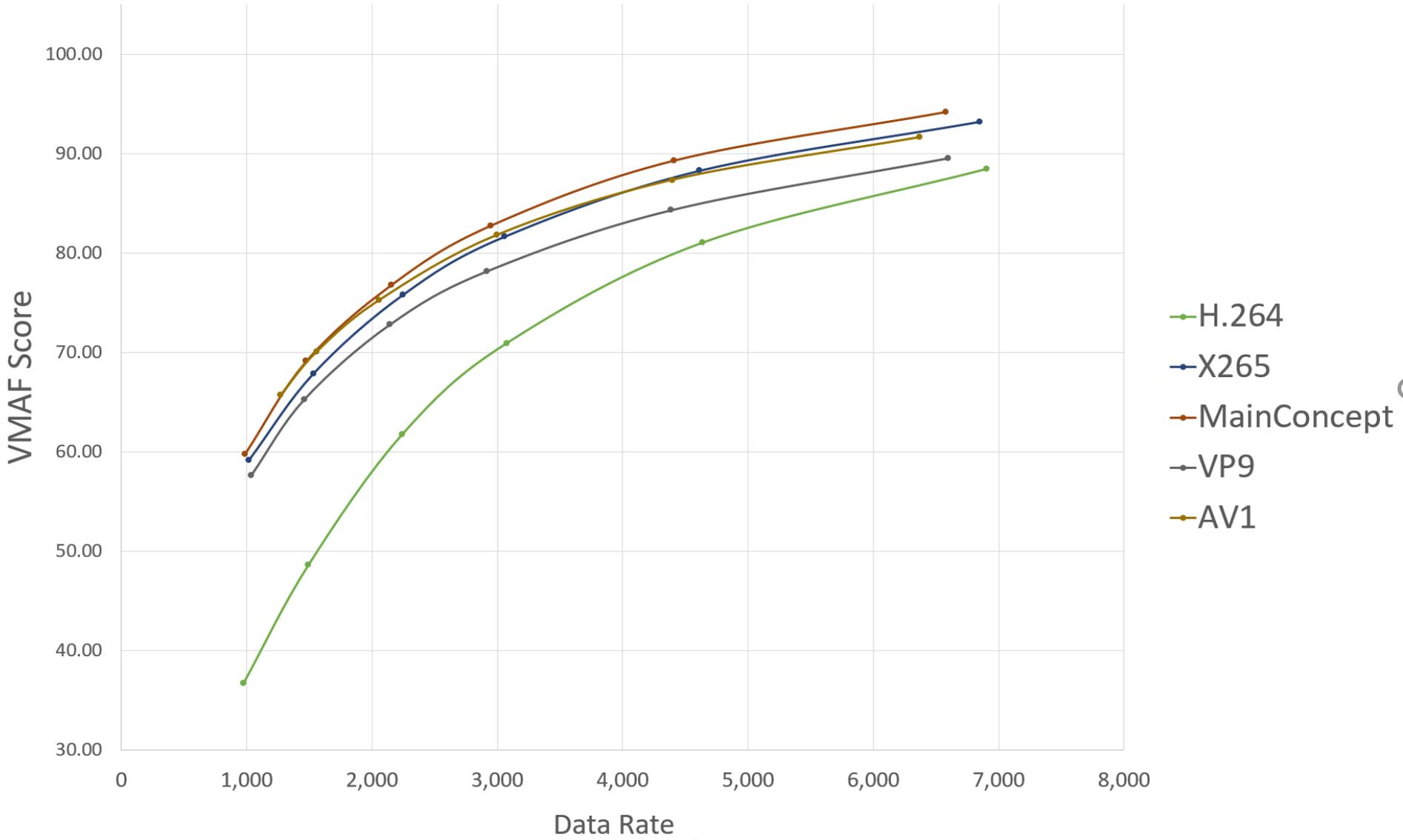


720p Aggregate

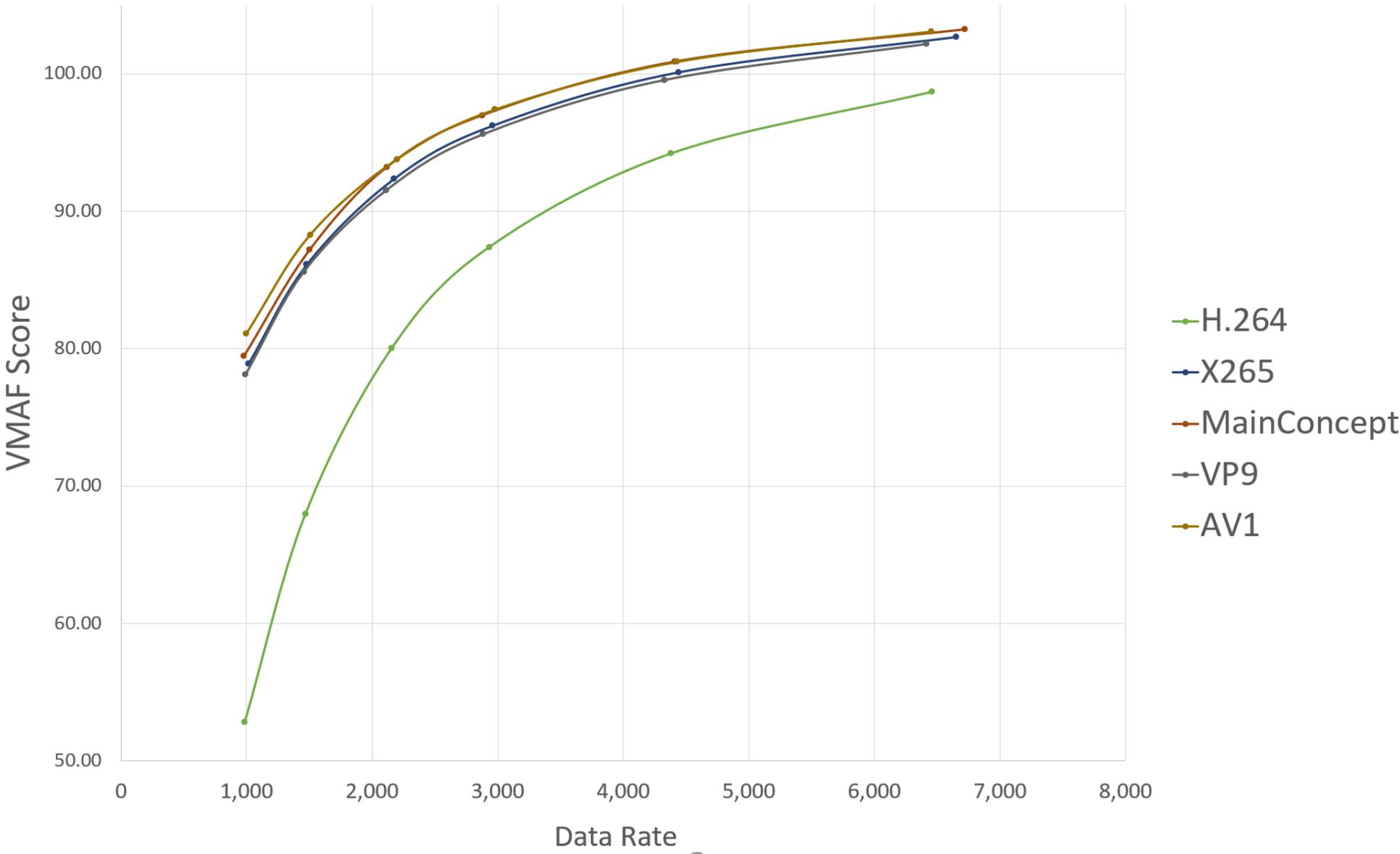


720p	H.264		x265		MainConcept		VP9		AV1	
450 kbps	450	63.22	455	78.63	444	79.08	453	76.96	579	82.94
675 kbps	673	73.47	681	84.85	666	86.02	672	83.02	789	87.07
1 Mbps	1,003	82.23	1,005	90.12	968	91.10	998	88.43	1,109	91.04
1.5 Mbps	1,509	89.33	1,504	94.54	1,454	95.35	1,497	93.10	1,604	94.52
2.2 mbps	2,195	94.18	2,207	97.80	2,141	98.41	2,187	96.51	2,240	97.39
3 Mbsp	3,016	97.35	3,021	99.83	2,917	100.31	2,981	98.77	3,119	99.89

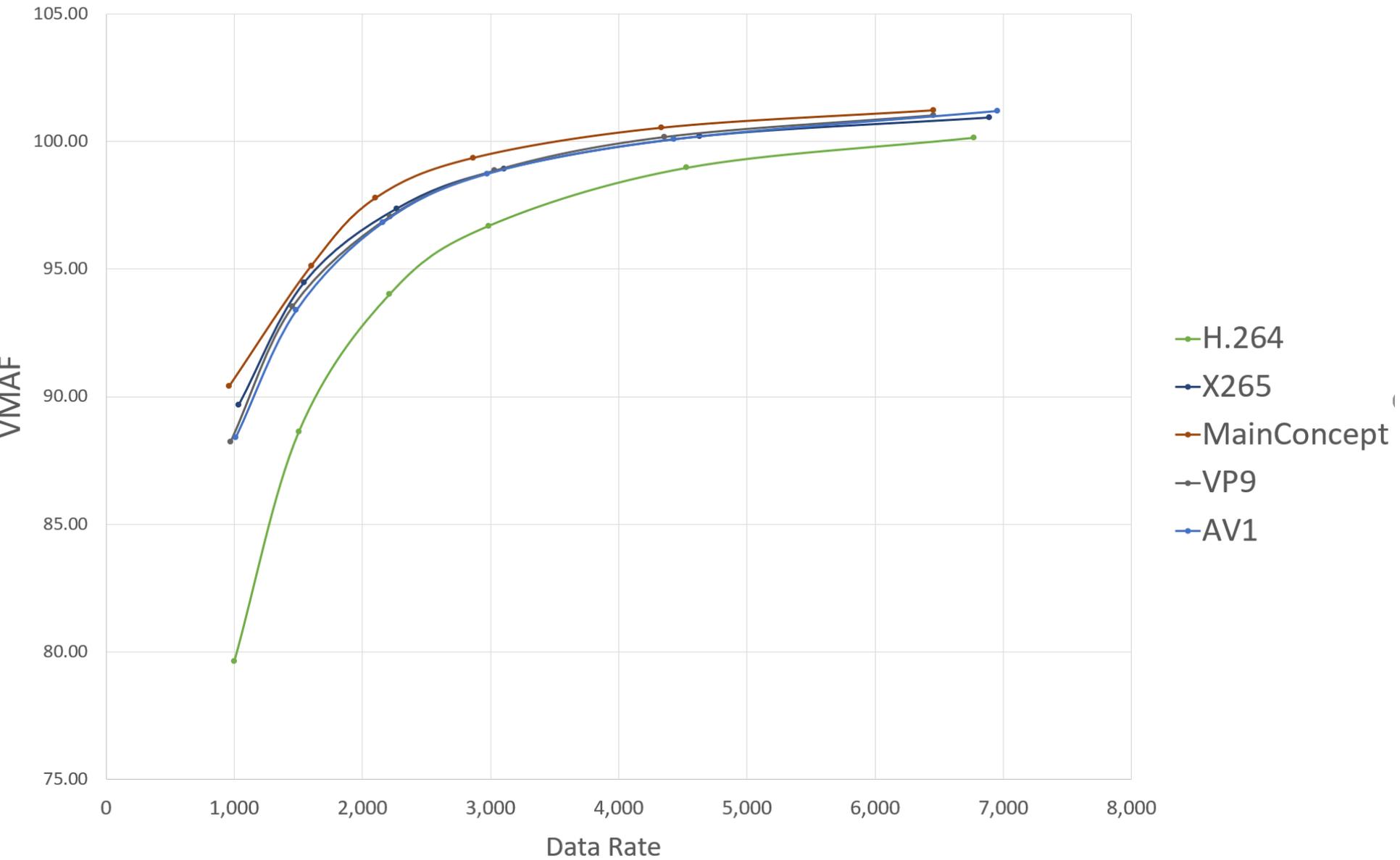
Boat Clip - 1080p



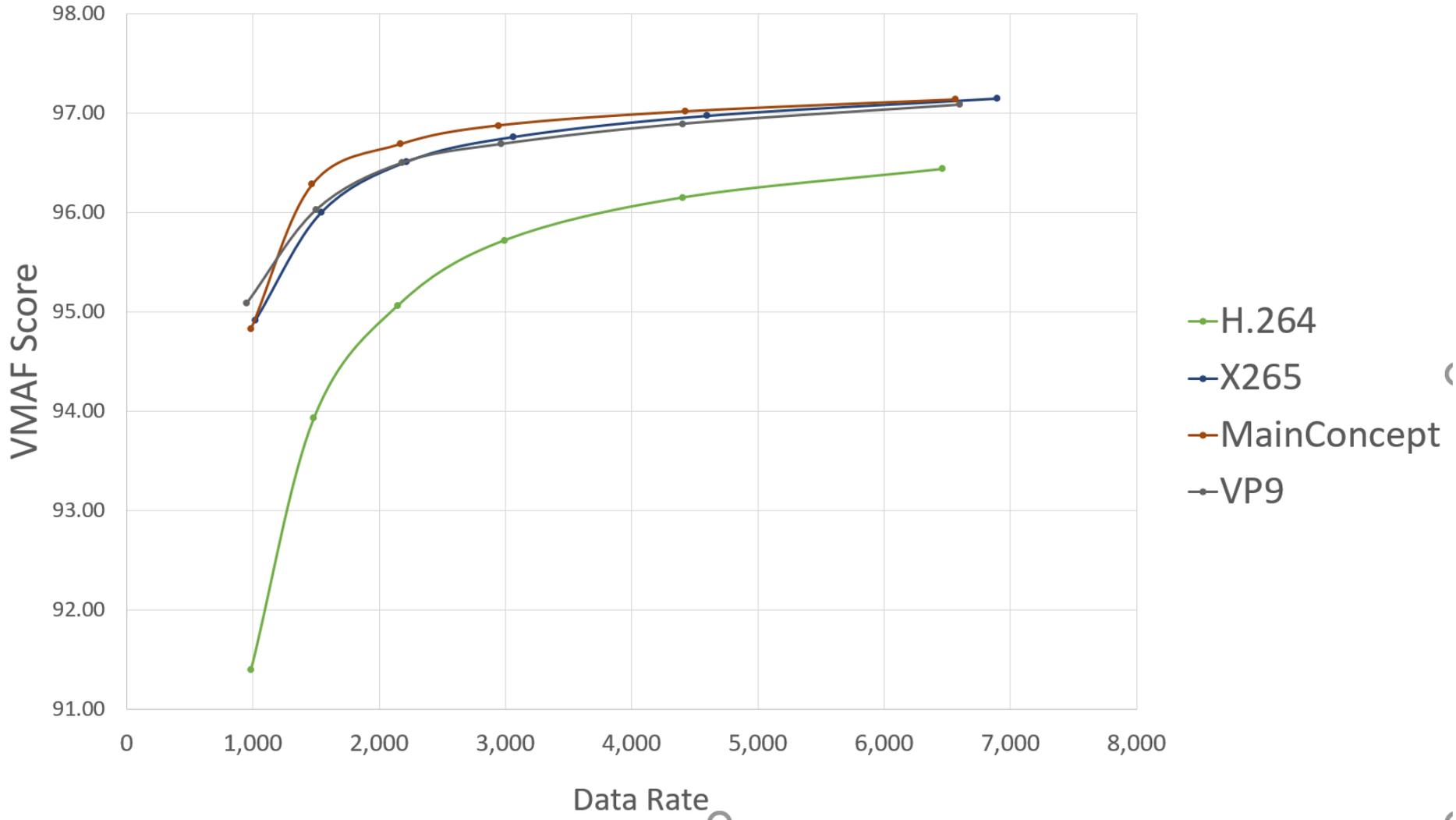
FoodMarket Clip - 1080p



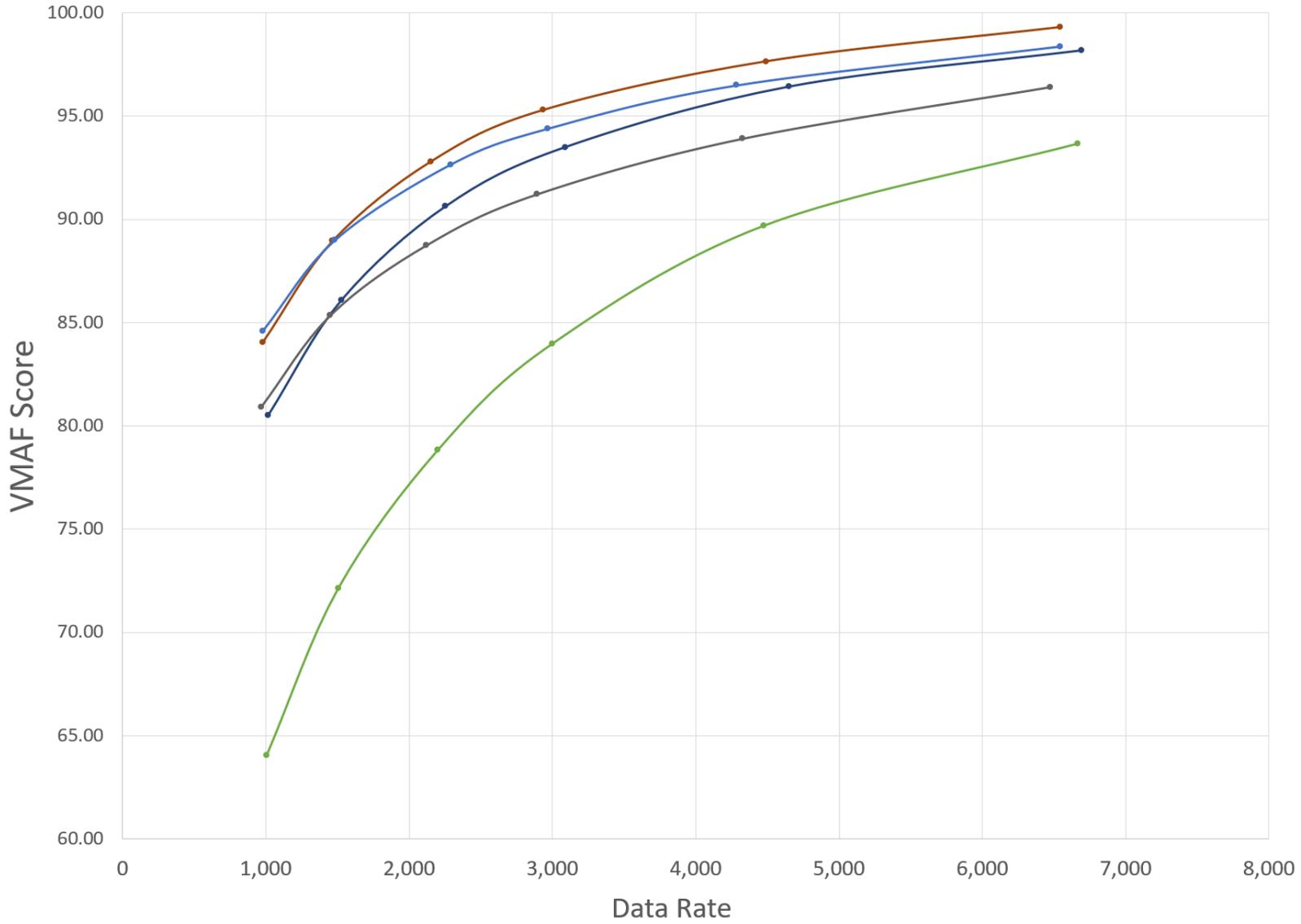
Forklift Clip - 1080p



Liquor Clip - 1080p

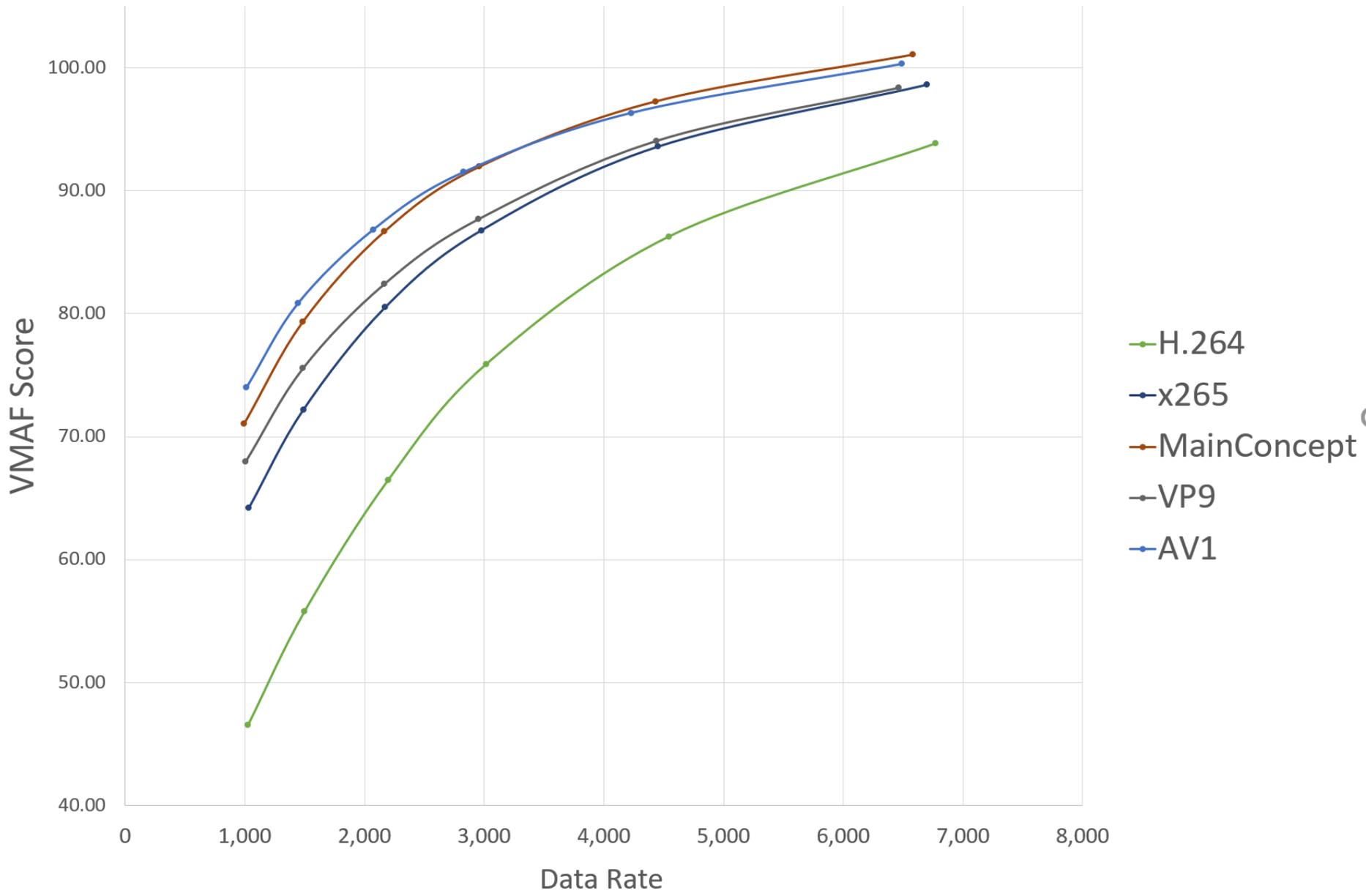


Pier Clip - 1080p

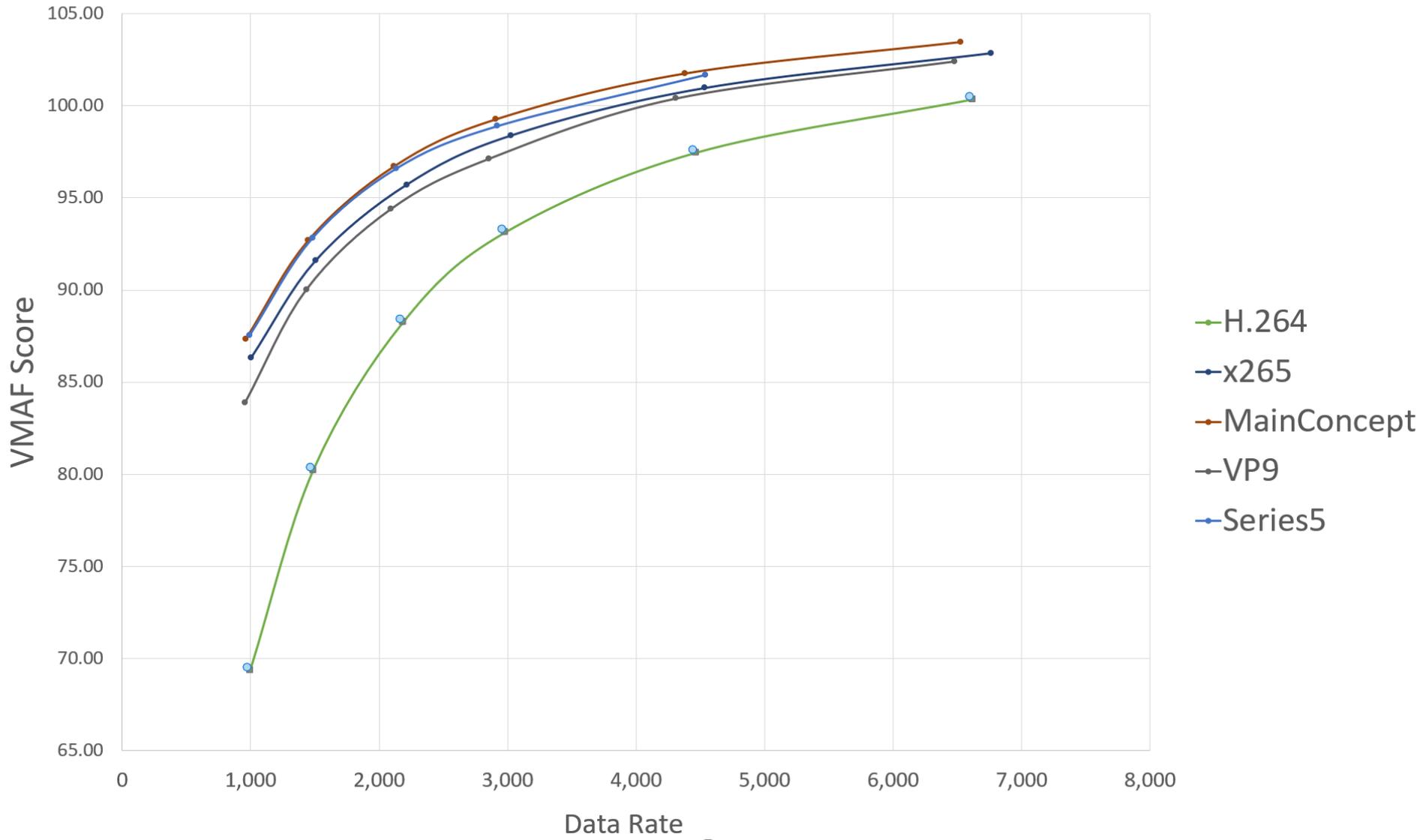


- H.264
- x265
- MainConcept
- VP9
- AV1

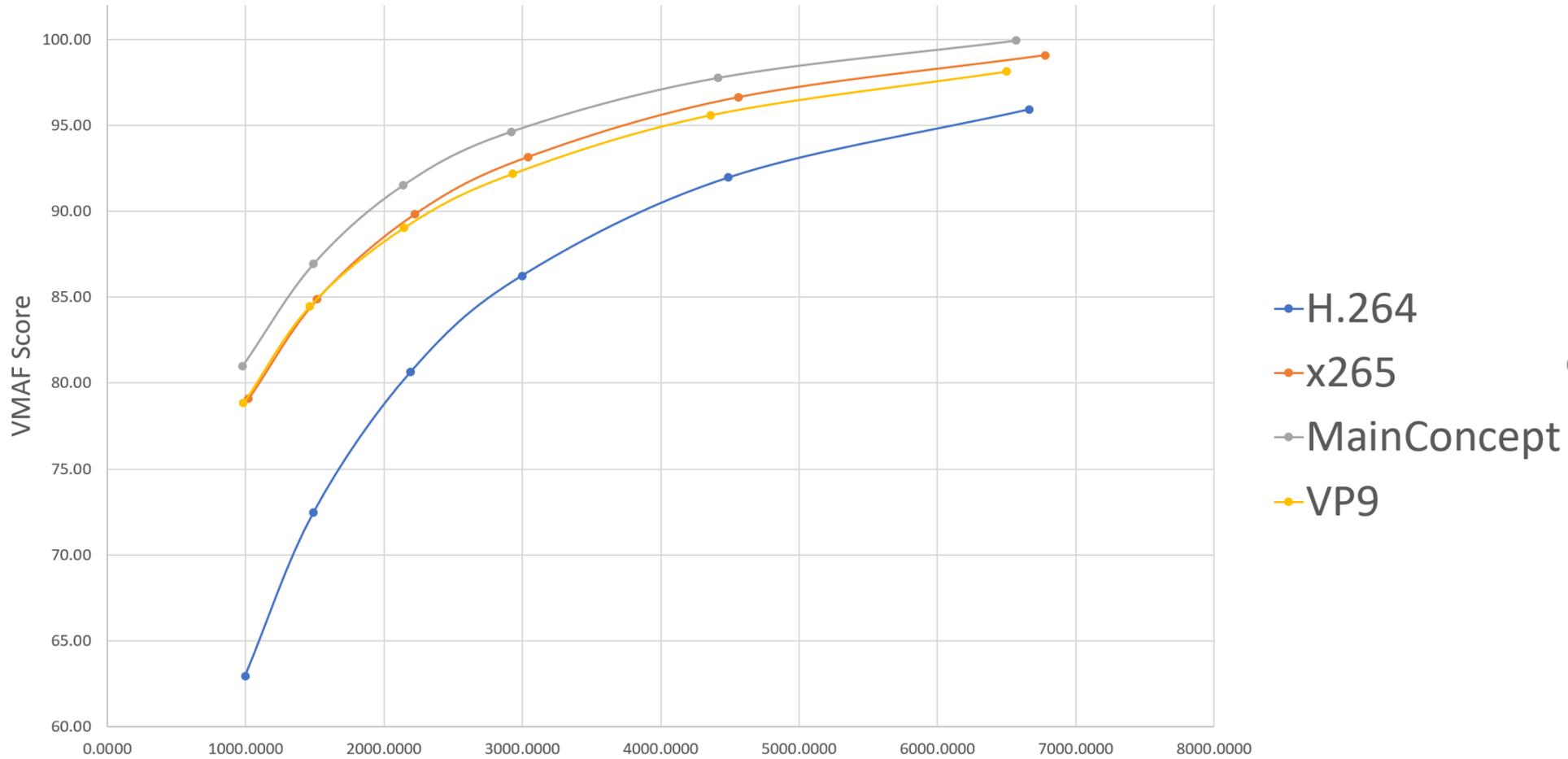
Ritual Clip - 1080p



Sintel Clip - 1080p

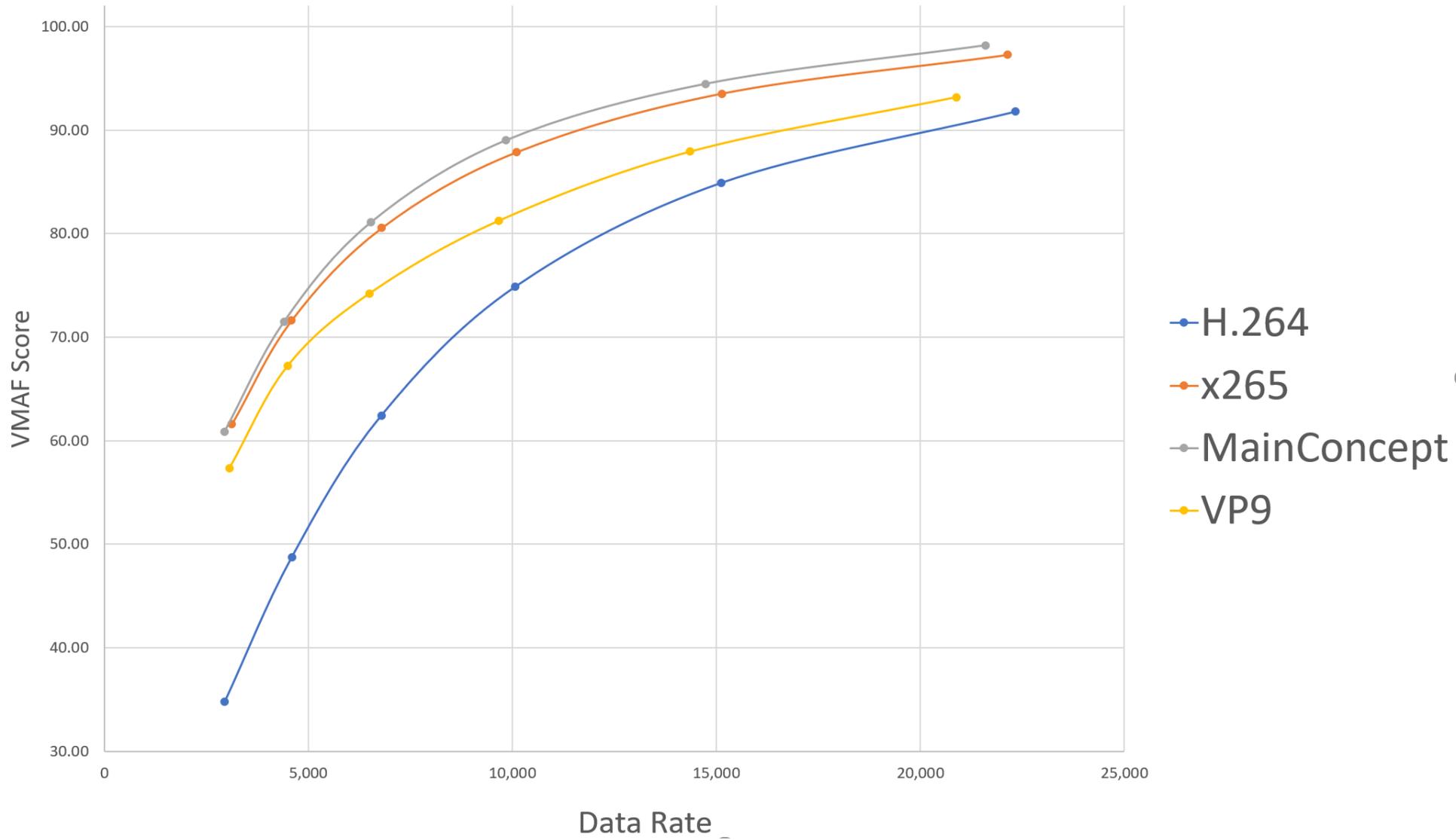


1080p Aggregate

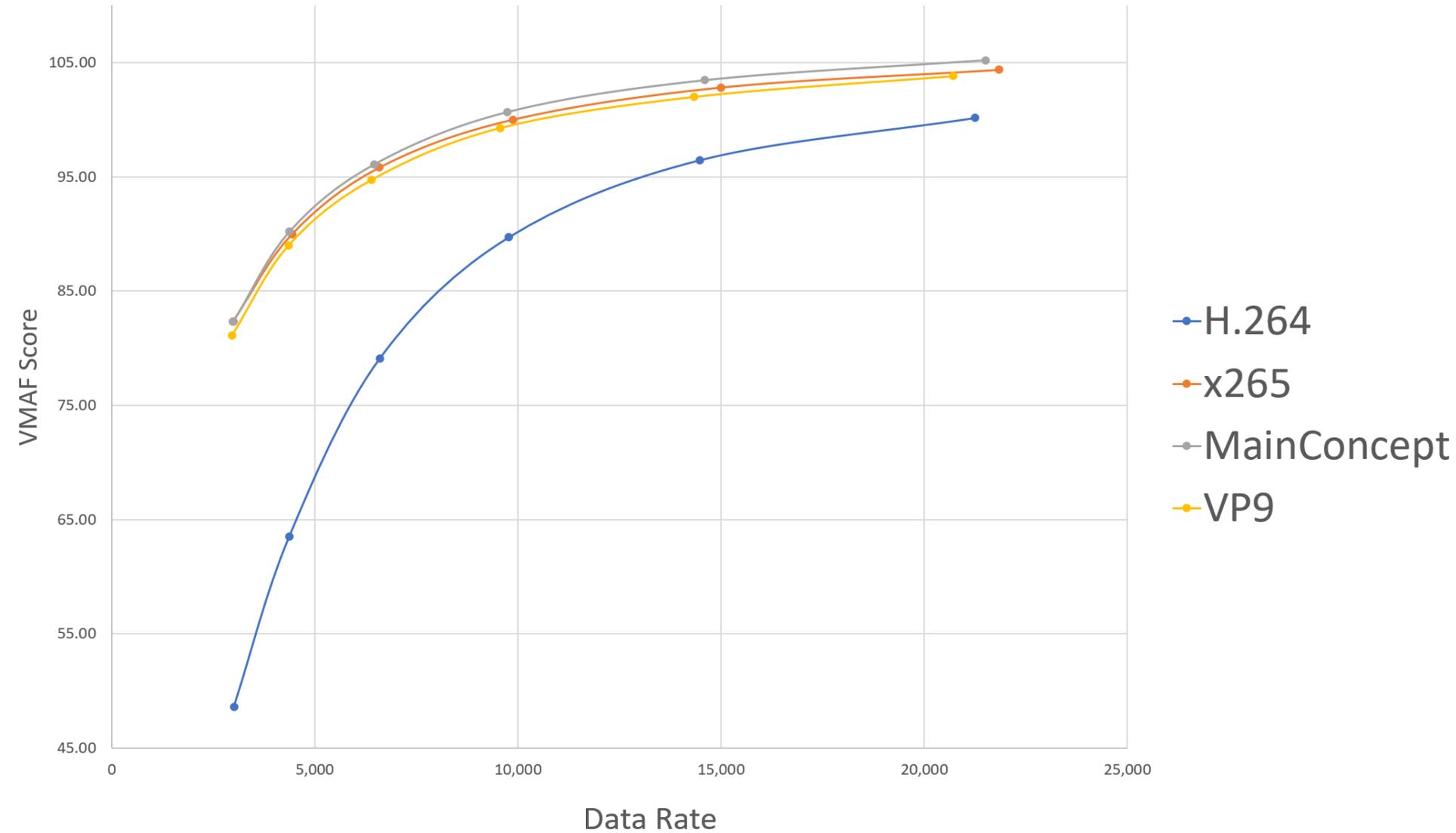


1080p			x265		MainConcept		VP9	
1 mbps	996	62.93	1,020	79.09	977	80.99	983	78.83
1.5 mbps	1,492	72.48	1,518	84.91	1,491	86.96	1,463	84.48
2.2 mbps	2,192	80.63	2,222	89.84	2,140	91.53	2,146	89.06
3 Mbps	2,997	86.24	3,040	93.17	2,919	94.64	2,928	92.19
4.5 mbps	4,491	91.96	4,561	96.64	4,412	97.77	4,364	95.61
6.7 mbps	6,665	95.93	6,778	99.09	6,568	99.94	6,498	98.14

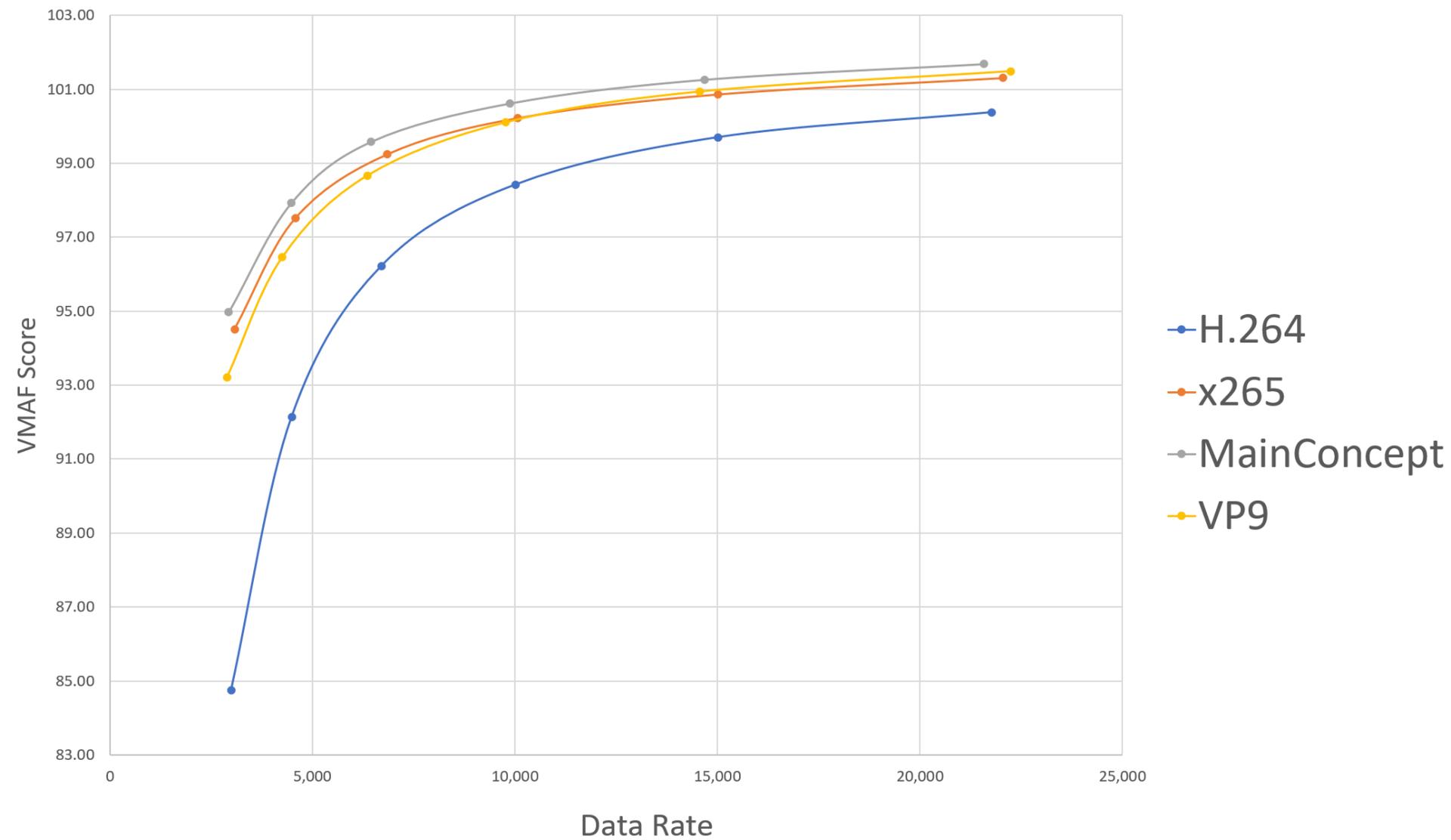
4K Boat



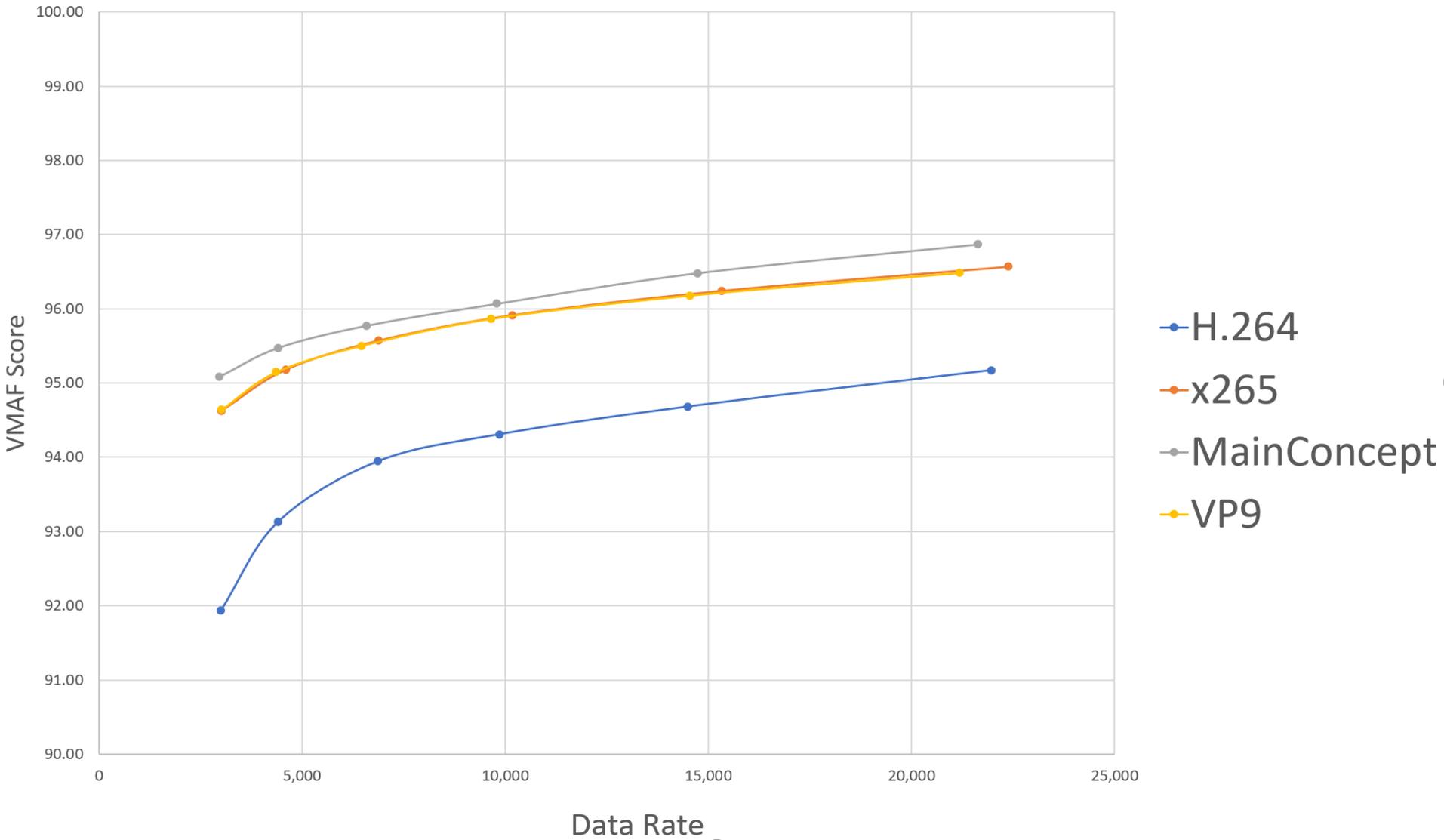
4K Food Market



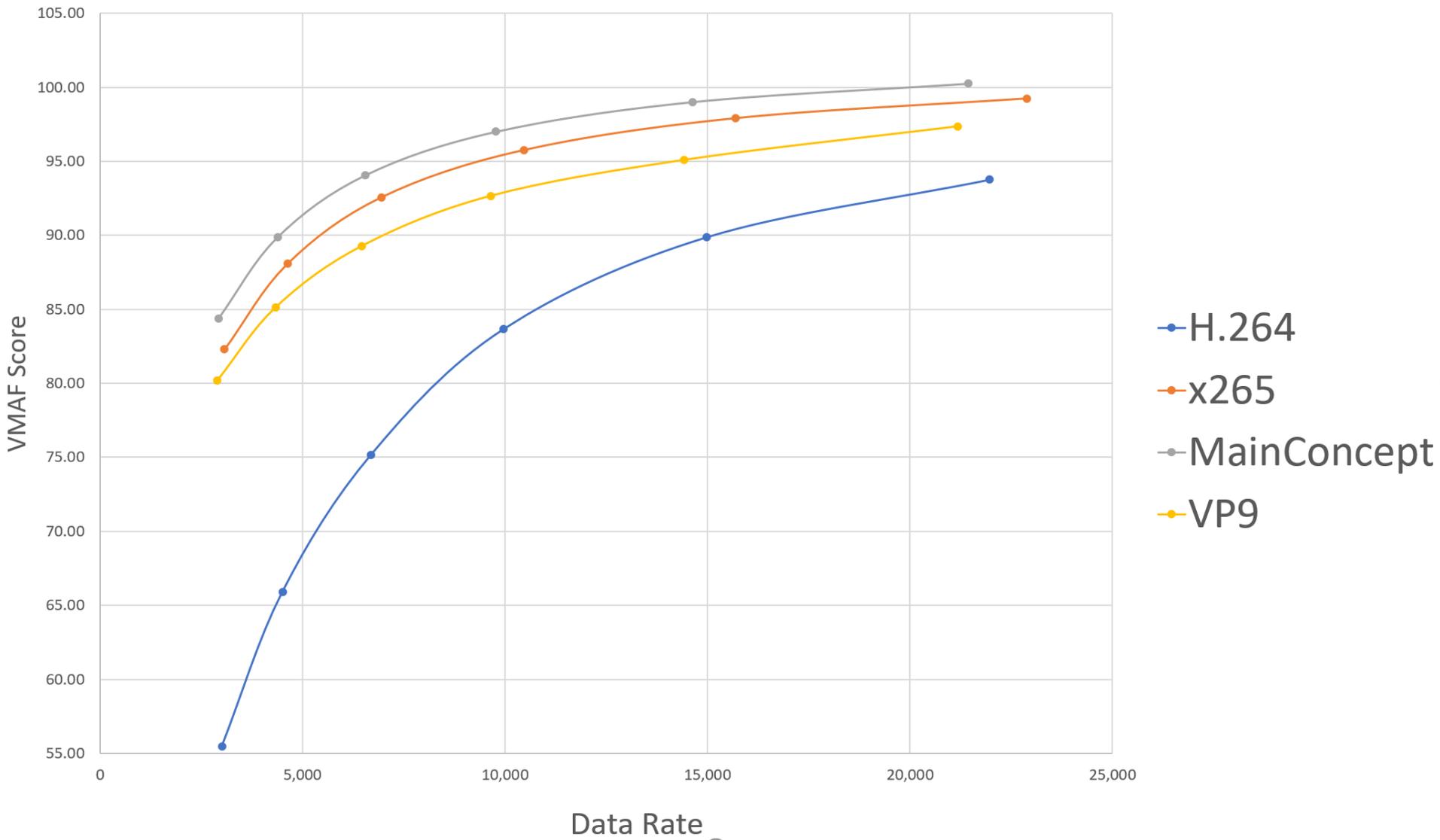
4K Fork Lift



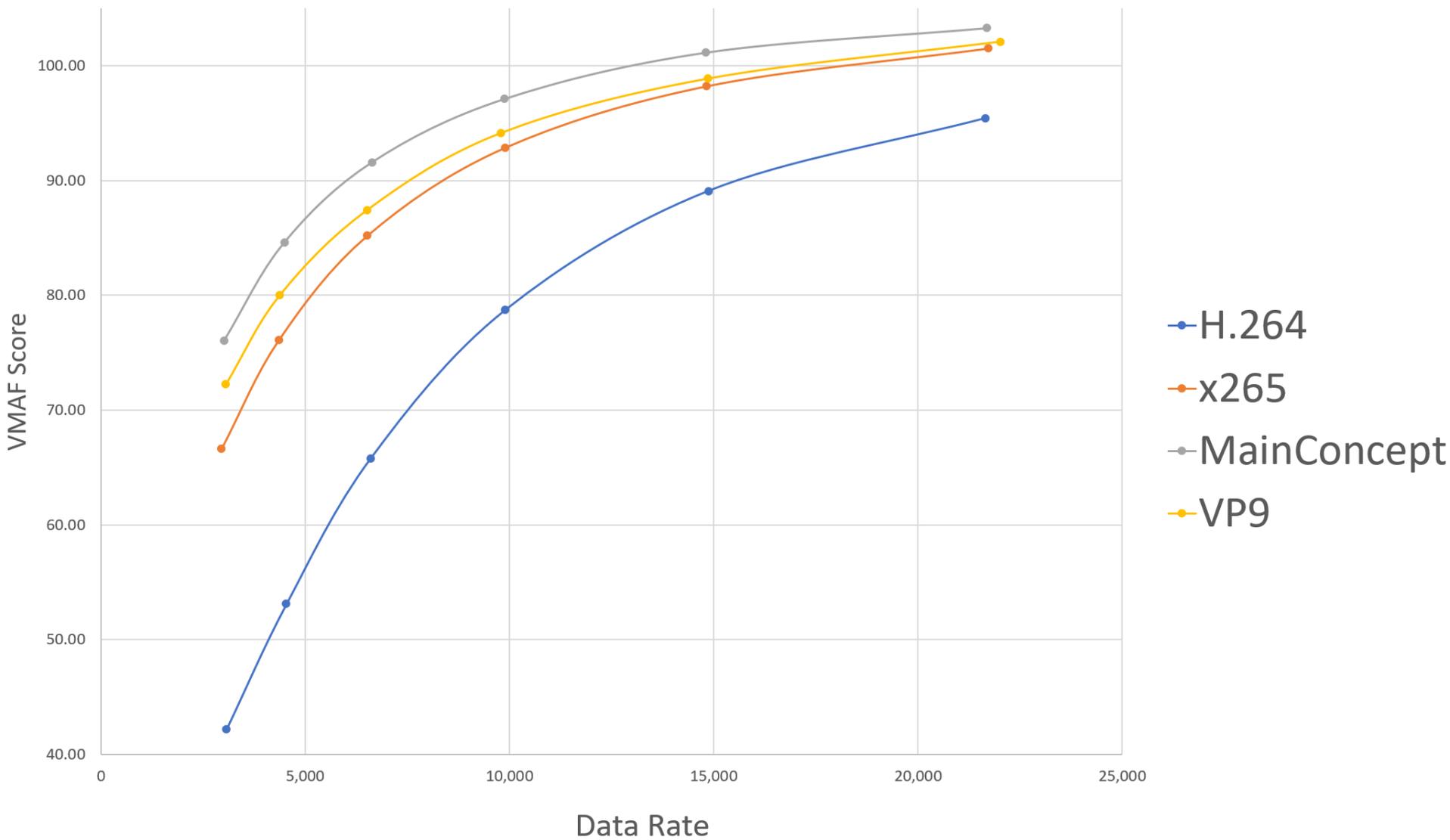
4K Liquor Store



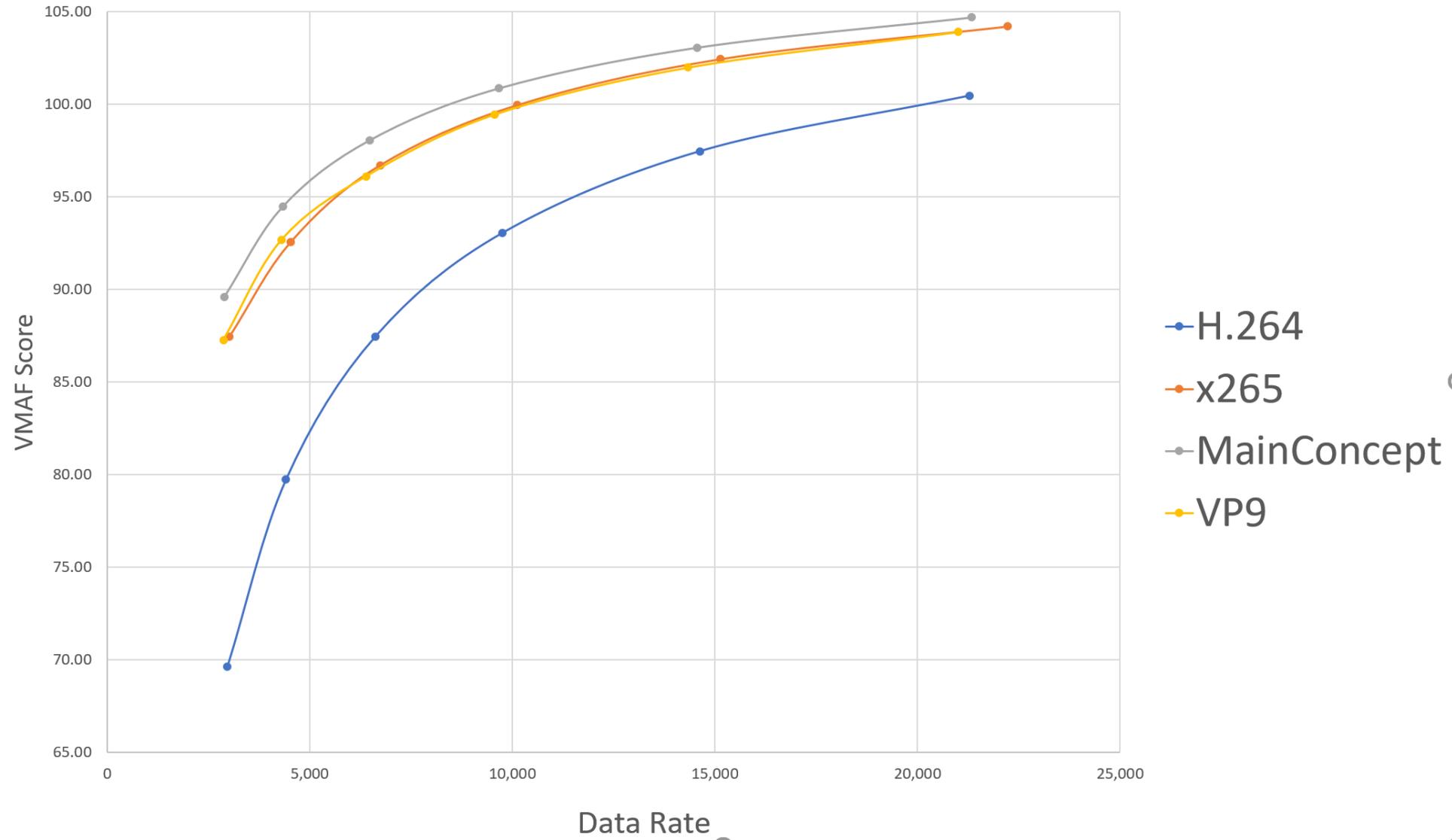
4K Pier



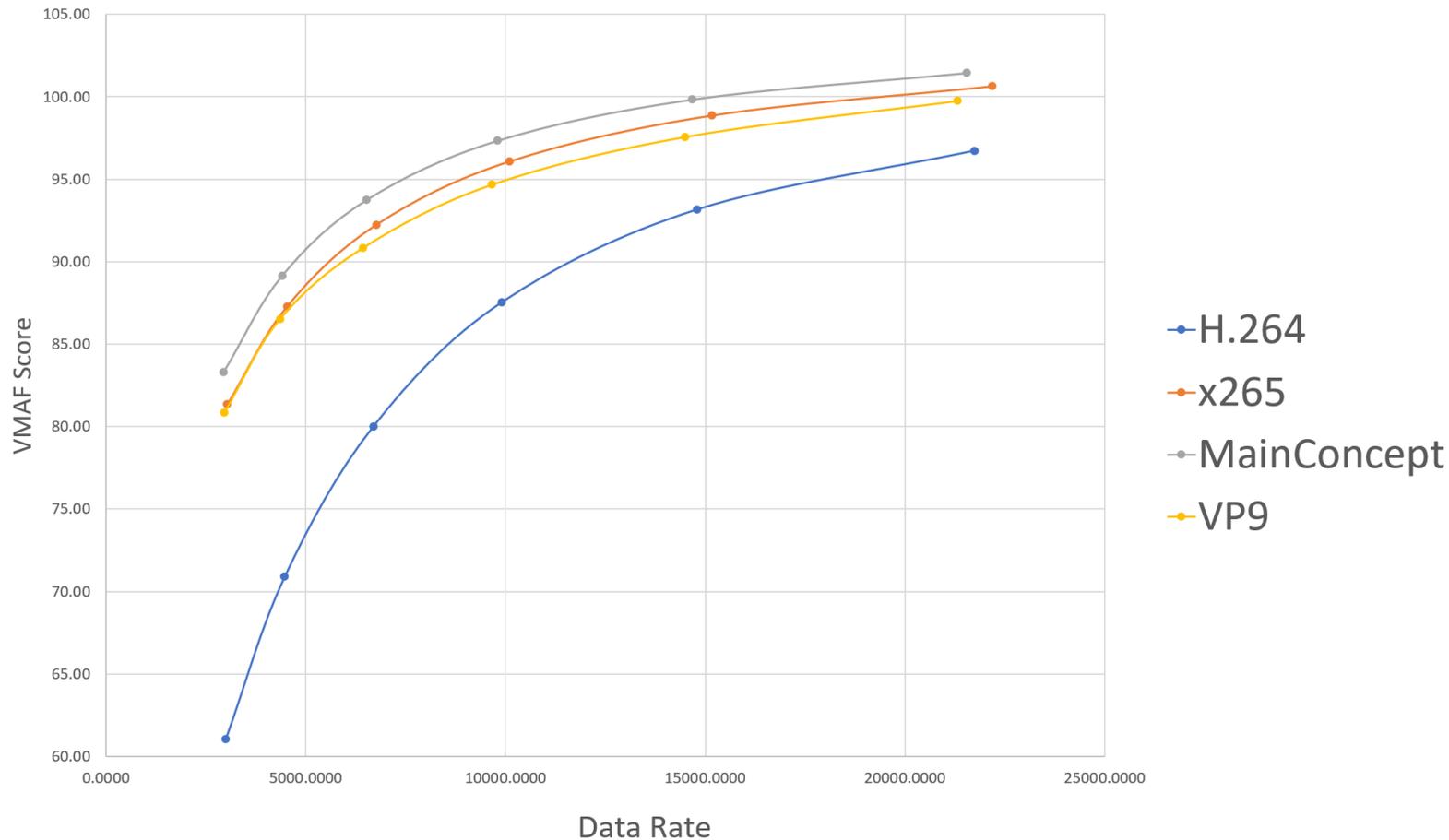
4K Ritual Dance



4K Sintel



4K Aggregate



4K	H.264		x265		MainConcept		VP9	
3 mbps	2,999	61.05	3,037	81.35	2,947	83.31	2,962	80.86
4.5 mbps	4,474	70.90	4,531	87.30	4,411	89.16	4,351	86.53
6.7 mbps	6,694	80.01	6,760	92.24	6,527	93.75	6,436	90.85
10 mbps	9,906	87.54	10,100	96.09	9,795	97.34	9,663	94.68
15 mbps	14,798	93.17	15,160	98.86	14,678	99.84	14,491	97.57
22 mbps	21,744	96.73	22,179	100.64	21,545	101.45	21,316	99.76

Conclusions

- The qualitative difference between Main Concept and x265 was minimal, particularly with VMAF
- VP9 appears to be falling behind a bit
- Need to redo AV1 encodes
- Comments from MainConcept/MulticoreWare