Motion Estimation Tuning Cheat Sheet

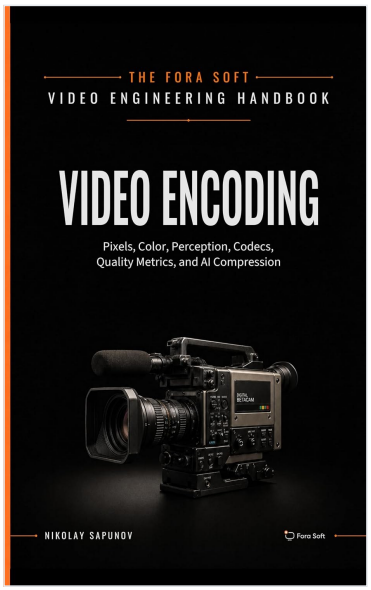
What each codec exposes, default values, and which knobs move the needle on bitrate vs quality.

Companion to: 'Temporal Pixel Correlation: Redundancy Between Frames'

Knob	x264 (H.264)	x265 (H.265)	SVT-AV1	VVenC (H.266)	Why it matters
Search method	me=hex (default) best: umh or esa	me=hex,umh,umh (HME) best: star or full	implicit (controlled by preset)	implicit (controlled by preset)	Wider patterns find better matches but cost CPU. Default is fine for talking-head; raise on sports.
Search range	merange=16 (default) max 64	merange=16/32/48 (HME levels)	n/a (preset-controlled)	n/a (preset-controlled)	Max pixel radius of motion search. Raise for 4K + high motion; lower for surveillance.
Sub-pel precision	1/4-pel luma 1/8-pel chroma	1/4-pel luma 1/8-pel chroma	1/8-pel luma	1/16-pel luma (affine sub-block)	Fractional-pixel matching catches real-world motion that integer vectors cannot. Always on.
Reference frames	ref=3 (default) max 16	ref=3 (default) max 16	max 7	max 4 (typical)	More refs help on scenes that repeat; diminishing returns past ~5 on most content.
B-frames per GOP	bframes=3 (default)	bframes=4 (default) b-pyramid on	implicit (per preset) b-pyramid	implicit (per preset) hierarchical RA	B-frames are the cheapest, but raise decoder buffer + latency. Keep at default for VOD; off for live.
GOP / keyint	keyint=250 (default) 10s @ 25 fps	keyint=250 (default)	keyint=5s typical	keyint=5s typical	One I-frame every 2-10s. Shorter = bigger files, faster seek. Don't shorten to fix latency.
Motion model	translational only	translational only	translational + warped + global motion + OBMC	4/6-param affine + SbTMVP + BDOF + DMVR	Newer codecs describe rotation, zoom, and shear without sending thousands of MVs.
Preset / speed	preset slow / medium / fast	preset slow / medium / fast	preset 0-13 (slower-faster)	preset slow / medium / faster	The single biggest dial. 'slow' typically saves 15-25% bitrate vs 'fast' at equal quality.

If you only change three things:

1. Move the preset one notch slower (medium -> slow) before raising bitrate. It is almost always the cheapest win.
2. Keep the keyframe interval at 2 seconds for streaming. Shorter raises bitrate by 20-35% with negligible latency benefit.
3. Enable hierarchical B-frames (b-pyramid) for VOD. Disable B-frames entirely only when end-to-end latency is < 200 ms.



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This sheet lines up motion search, sub-pel, references, B-frames and presets across x264, x265, SVT-AV1 and VVenC. Volume 1 explains the redundancy these knobs exploit: inter prediction and motion vectors, GOP structure, rate control and how to measure the bitrate saved at equal quality.

WHAT YOU WILL FIND INSIDE

- Inter prediction, motion vectors and sub-pel search
- GOP structure and hierarchical B-frames
- Preset trade-offs in x264, x265 and SVT-AV1
- Measuring savings with VMAF and BD-rate

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