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by Frank Seto and Dale Stolitzka

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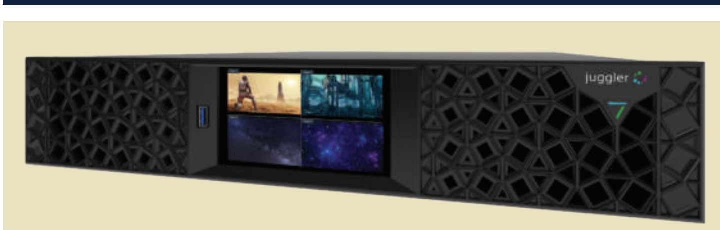

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ClearMR 1.1—Improving the VESA Standard Method for Measuring Motion Blur

The standard has several upgrades, leading to more efficient testing and a tighter statistical variance in results.

by **Frank Seto and Dale Stolitzka**

UNLIKE OTHER COMPLIANCE SPECIFICATION UPDATES released by VESA, ClearMR 1.1—a standard that quantifies edge-motion blur by objective means—contains no new tests or test limits. Instead, it has several upgrades that result in more efficient testing and a tighter statistical variance in results. The improvement and method are being shared with the knowledge that the same processes may improve similar testing where noise in the signal is an obstacle to obtaining reliable results.

The new method leverages a signal processing technique commonly seen in medical equipment, where a signal must be extracted from noise without distorting the signal shape and characteristics. In electronics, filtering usually serves a similar function, but in most cases, such frequency tuning can be expensive and often reduces signal swing. In testing for motion blur, it is impractical to limit the main signal since overshoot is an important blur mitigation technique, but one that may cause ghosting when applied to the extreme.

The Clear Motion Ratio (CMR) metric remains the principle foundation of the ClearMR standard. It provides an objective, numerical value based on the ratio of clear pixels to blurry pixels. The new version of ClearMR is fully backward compatible to the original.

ClearMR Overview

The CMR metric forms the basis for measurement of motion blur. VESA originally released version 1.0 of the ClearMR Compliance Test Specification in August 2022. It is an industry standard and logo program that provides consumers with a true quality metric for grading motion blur performance on TVs, desktop monitors, and laptop displays, most commonly using LCD or OLED panels. The CMR metric defined in the ClearMR standard provides an objective, numerical value based on the ratio of clear pixels to blurry pixels—enabling consumers to clearly compare the amount of motion blur between ClearMR-certified displays and across different panel technologies.

The latest version of the specification, ClearMR 1.1, contains important upgrades to the testing process that make testing faster and fairer because VESA introduced powerful statistical means to reduce test variances. This article will discuss why using new methods benefits those performing certification testing, manufacturers, and ultimately the end user. To overview ClearMR's underlying concepts, refer to the authors' earlier article.[1]

BACKGROUND

ClearMR was designed to replace multiple pre-existing metrics developed by the display industry, such as refresh rate (Hz) and frame rate (ms). Refresh rate is a poor indicator of motion clarity performance (**Fig. 1**). For example, for a particular 240-Hz refresh rate display, there could be a wide range of ClearMR performance—from 6,000 to more than 13,000! At the lower end of the spectrum, the performance would be on par with

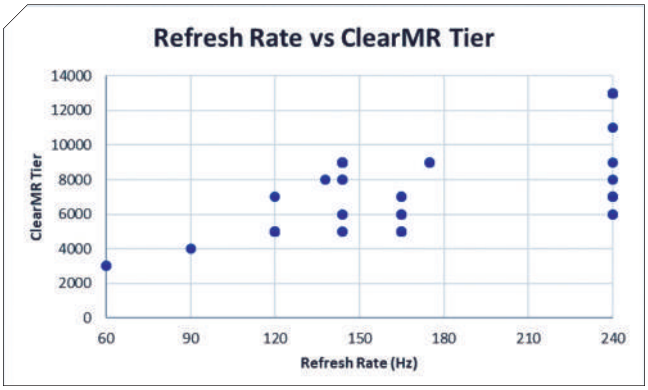


Fig. 1.

Refresh rate versus ClearMR tier.[2]

the better performance of 120-Hz displays. This is because the refresh rate is only part of the equation in terms of motion clarity.

Likewise, there are a number of response time metrics, such as gray-to-gray (GtG) and moving picture response time (MPRT); however, the results are all displayed in ms, and manufacturers each have their own method for testing. The advertised number should be a worst-case maximum, but this is more often a typical value at a particular test condition that is rarely cited and could be manifested only when unusual overdrive has been applied.

Cutting through the cloud of confusion, ClearMR provides both a standardized testing method and a certification program—allowing consumers to make informed decisions.

Technical Improvements

In concept, ClearMR optically measures an edge in motion by a process called digital pursuit by the Information Display Measurements Standard (IDMS).[3] It employs a high-speed camera to capture a moving bar pattern in multiple still image frames at a predetermined rate set by the pixels-per-frame (PPF) bar speed and the display frame rate.

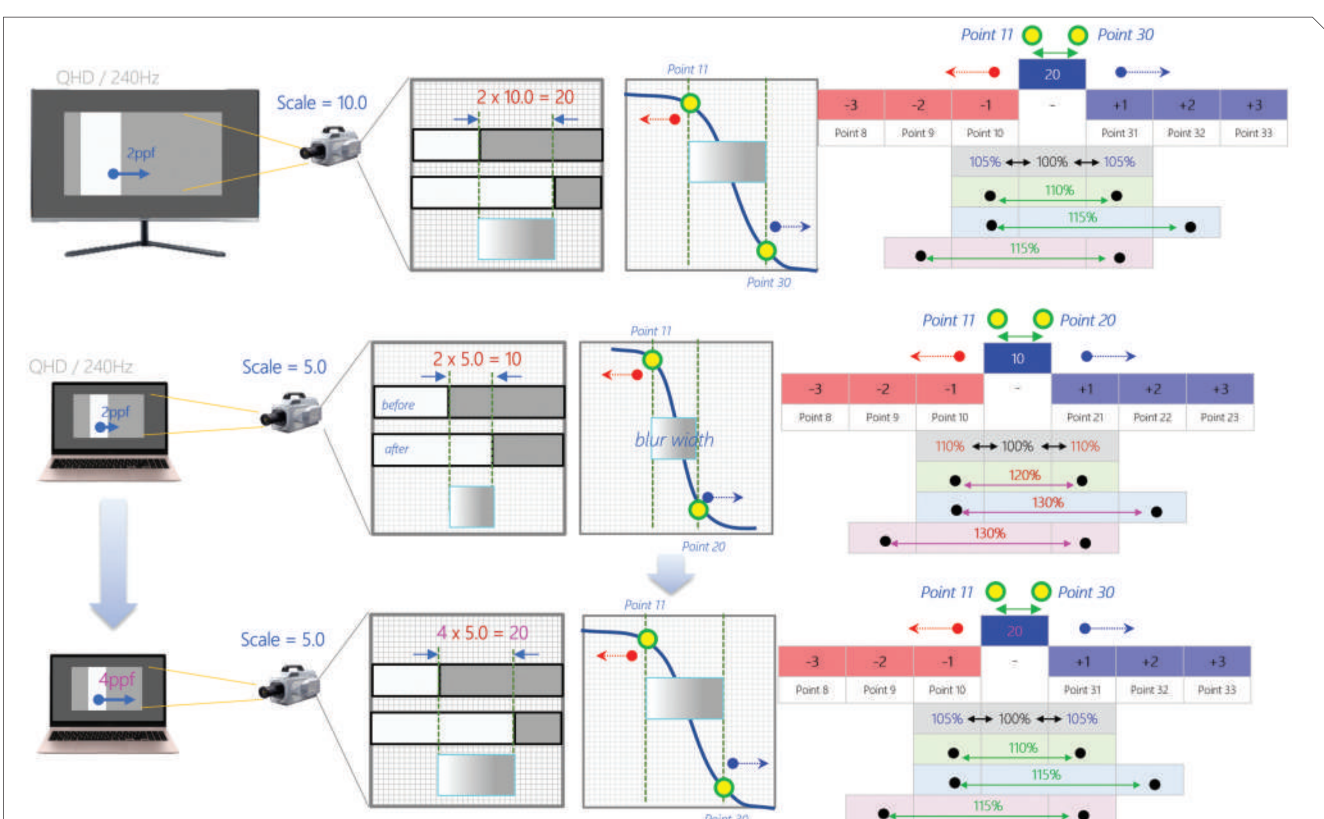
As a direct measurement of optical performance, digital pursuit offers great accuracy, yet carries unique challenges. In particular, the setup is sensitive to optical-to-electrical noise, which can impact the final result by requiring more measurements to meet the coefficient of variation (CV) requirement (described later in this article). There could be many factors that would induce noise, such as micro-vibration during capture, lens quality, or sensor noise. While some of those factors may be abated, the better approach VESA took is to accept that some noise will be present and then design the procedure to prevent the noise from influencing the test result.

To overcome high-speed digital pursuit challenges, two proposals became the essence of ClearMR 1.1:

- First, level the playing field across display sizes. Smaller

Fig. 2.

Difference of 1 pixel depending on the scale (top: high scale, middle: low scale, bottom: low scale with compensated PPF).



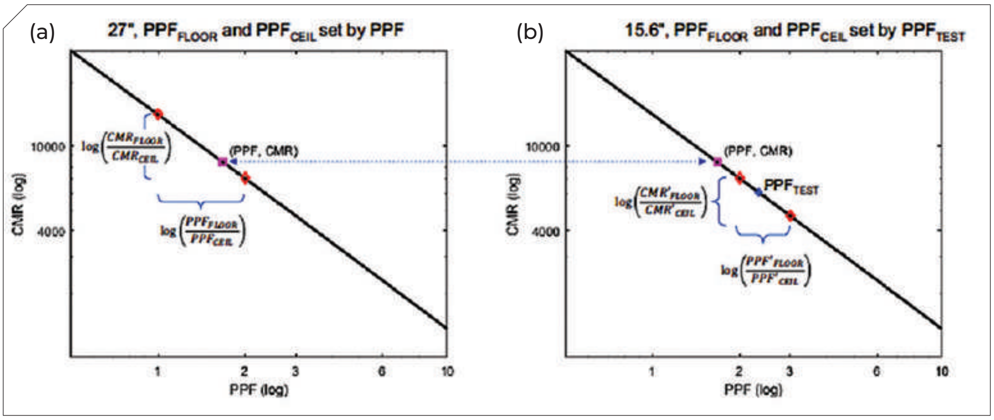


Fig. 3.

Example of logarithmic interpolation to derive CMR at PPF, in which PPF_{Floor} and PPF_{Ceil} are set by (a) PPF versus (b) PPF_{Test}.

$$\alpha = \frac{M_{ideal} \times PPF + 1}{M_{ideal} \times PPF - 1} \qquad (1)$$

displays with higher pixel density were measured with far fewer camera pixels than larger display counterparts. The effect allowed optical noise to introduce a more significant error—and greater disadvantage—to smaller displays. The new proposal (discussed in the next section) overcame the inherent disadvantage and at the same time allows for testing displays at ultrahigh frame rates (above 300 Hz).

- Second, introduce a statistical averaging method to take noise out of the equation. Referred to as ensemble averaging, the approach is based in health science and removes noise from a repetitive signal. This method increases robustness against noise and improves the consistency of results, as described in the next section.

Notably, these upgrades were introduced while ensuring compatibility with previous results.

ACCOMMODATION FOR SMALLER AND FASTER DISPLAYS

ClearMR 1.1 improves support for smaller and faster displays by mandating the test at a higher PPF count than in ClearMR 1.0. The final CMR score is extrapolated from two test points on a linear relationship. Ideally and mathematically, the result is the same, but with a higher confidence level.

Referring to **Fig. 2**, when comparing the top and middle rows, while both displays have the same resolution and frame rate, the smaller size screen (middle) is at a disadvantage because the blur width is spread over fewer camera sensor pixels. If there is a minor error induced by even one camera pixel, it would propagate into a higher percentage error compared to the bigger display with lower magnification.

Now compare the top and bottom rows, where it is clear that the disadvantage is mitigated. To equalize the two scenarios, ClearMR 1.1 introduced a set of conditions to allow for measuring at the higher PPF so that any noise effect would be equal between the two. The difference between the ClearMR 1.0 and 1.1 approaches can be seen by comparing the middle and bottom rows in **Fig. 2**.

Measurement is based on Equation 1, where M_{ideal} is the ideal magnification and *PPF* is the ideal PPF; the relationship of the two is calculated with a 1-pixel tolerance to derive the ratio α.

If α is over the limit of 110 percent, the *PPF* is adjusted until that limiting condition can be met. The resulting *PPF* is called PPF_{TEST}.

PPF_{TEST} is often a real number. Because *PPF* only can be measured at natural number intervals, PPF_{TEST} effectively determines the upper and lower bound of the *PPF* that is measured (**Fig. 3b**). By enforcing that *PPF* should be at least one, this same concept can be used when the PPF_{TEST} value is less than one, such as full high-definition displays with a 480-Hz refresh rate.

ENSEMBLE AVERAGING

When creating the blur profile, any noise in the capture—especially around the knee of the transition—can lead to large variance from one capture to another. Such variance can adversely affect the CV threshold, leading to the need for extra measurements to obtain a valid score.

In ClearMR 1.1, filter options such as Gaussian, Butterworth, and bi-lateral were considered. However, implementation success was lacking when tested across the multiple display technologies that apply for a certification. In the end, the solution turned out to be a health science technique—ensemble averaging (**Fig. 4**)[4]—that removes noise from a repetitive signal. This method is already used in monitoring applications such as heart rate, EKG, and ECG, where a single beat of the signal may be noisy, but when the signal is averaged over multiple beats in time, the true pattern emerges.

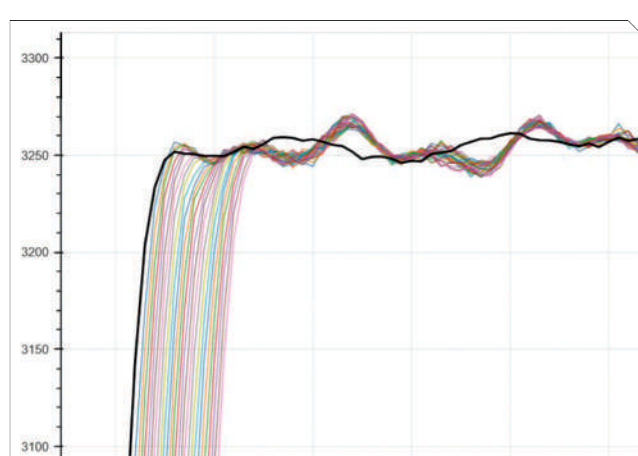


Fig. 4.

Ensemble-averaged (black) blur profile versus individual (color).

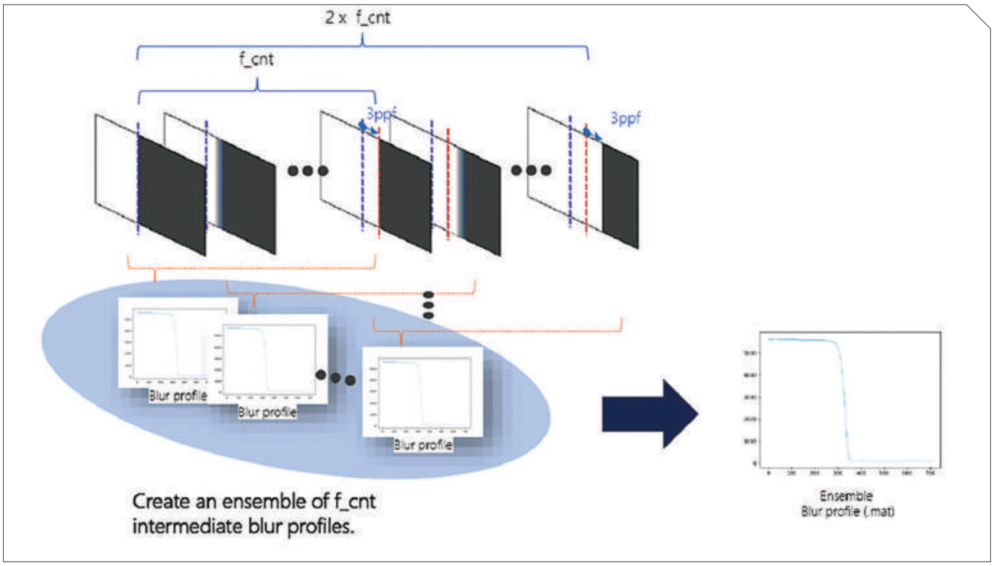


Fig. 5.

Creation of an ensemble-averaged blur profile from multiple blur profiles. Here, f_cnt represents the frame count (the number of frames required to capture an edge over a single frame update).

VESA integrated this method into ClearMR 1.1 with great success. As testing already used a series of images (an image stack) to create a single blur profile, successive frames of the blur profiles then can be used to create an ensemble-averaged blur profile by sweeping across the phase of the motion edge with respect to the camera capture (**Fig. 3**). The ensemble-averaged blur profile retains the shape of the source blur profile—in particular, near the blur edge—without introducing artifacts to the peaks. This method is unlike filtering, which would either dull or sharpen the blur edge, affecting the CMR score. Note that ensemble averaging is an average of the blur profiles, not a simple average of CMR scores.

Fig. 5 shows the creation of the ensemble-averaged blur profiles from multiple blur profiles, where f_cnt (frame count) is the number of frames required to capture an edge over a single frame update.

VALIDATION—MONTE CARLO SIMULATION

Because the overall CMR value consists of 14 different transitions across two PPFs, compounded by the number of offsets possible, it quickly becomes overwhelming to evaluate and visualize the overall impact. To facilitate this evaluation, VESA implemented a Monte Carlo simulation where each run comprises a random sampling of each transition. **Fig. 6** shows a distribution plot of each set of Monte Carlo simulations. The ensemble-averaged results (shown in blue) are seen to have a much tighter distribution (plotted along the top axis), with marked improvement in the average CV (plotted along the right axis).

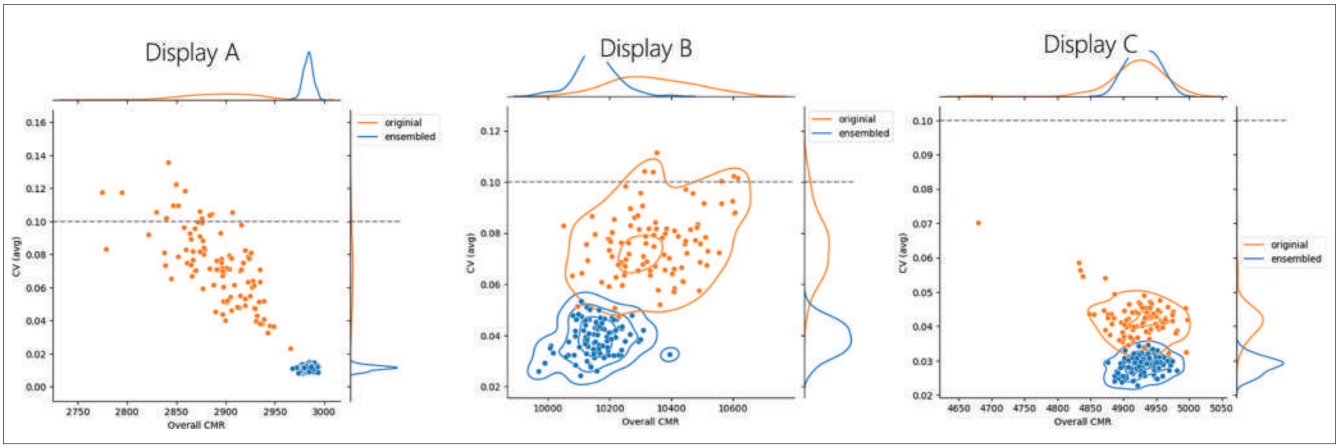
Recall that ensemble averaging is not an average of the previous CMR scores. **Fig. 6** shows examples where the final CMR scores may be higher, lower, or about the same as before, based on the characteristics of the blur profile. Where ensemble averaging is used, when there is a difference in CMR score, the cause typically is traced back to a visible difference in the captures.

Process Improvements

Whereas ClearMR 1.0 was about an open framework where the members can explore and understand how the results are calculated, ClearMR 1.1 is more about optimizing—and improving ease of use to—this framework. VESA incorporated a handful of features that further enhance a ClearMR test, ensuring continued adoption and success of ClearMR.

Fig. 6.

Ensemble-averaging Monte Carlo results.



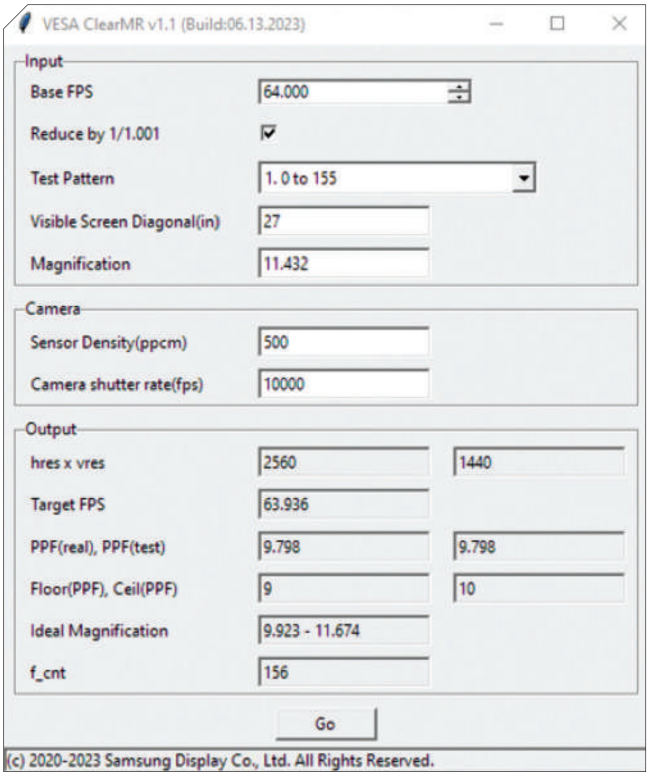


Fig. 7.

Screenshot of the ClearMR 1.1 pattern generator GUI, with auto-calculated parameters outlined.

IMPROVED PATTERN GENERATOR

Many features were added to the pattern generator. Most notable is the automatic calculation and checking of various parameters, such as PPF (test), ideal magnification range, and f_cnt. Previously, those parameters required manual calculation, which was tedious and error-prone. **Fig. 7** highlights these features included in the test generator graphical user interface (GUI).

The automatic calculation of these parameters also improved acceptance of the new proposals, since they did not complicate the test process.

OPTIMIZED CMR ANALYSIS TOOL

The CMR analysis tool received some notable upgrades. The most welcome is the ability to feed in a burst of capture images. Previously, each set of image captures only would generate one blur profile, forcing the operator to cut and save to multiple folders. With ClearMR 1.1, the tool generates a burst of ensemble-averaged blur profiles. VESA-authorized companies who provide test services—the authorized test centers (ATC)—now can feed in enough frames to generate multiple ensemble-averaged blur profiles as needed to meet the CV requirements in a single pass. Along with the guidance to review the capture data before saving the images, the new process substantially increases ATC workflow efficiency.

The other improvement is in the optimization of the CMR analysis tool. The previous version focused only on accuracy, not speed. The ClearMR 1.1 version not only has the same accuracy, but vastly reduced device test time. Compared to the original version, the program now runs twice as fast, despite processing more than double the number of frames for ensemble averaging. This gain is possible because of VESA member contributions to study the processing path and optimize for the calculation, while retaining the same accuracy.

Conclusion

VESA's ClearMR 1.1 specification shows that compliance test specifications can improve from the inside out, with the benefits of quicker test time, faster time-to-market for products, and improved test repeatability. VESA scrutinizes and trains each ATC in new skills to implement their test regimen. Because of the complex yet varied nature of display performance, VESA needs to own the display metrology and the result analysis that make up its certification program. The story of moving from ClearMR 1.0 to 1.1 is testimony to responsible ownership of these processes.

To learn more about this and other VESA specifications, be sure to attend Session 66.1 during Display Week 2024.

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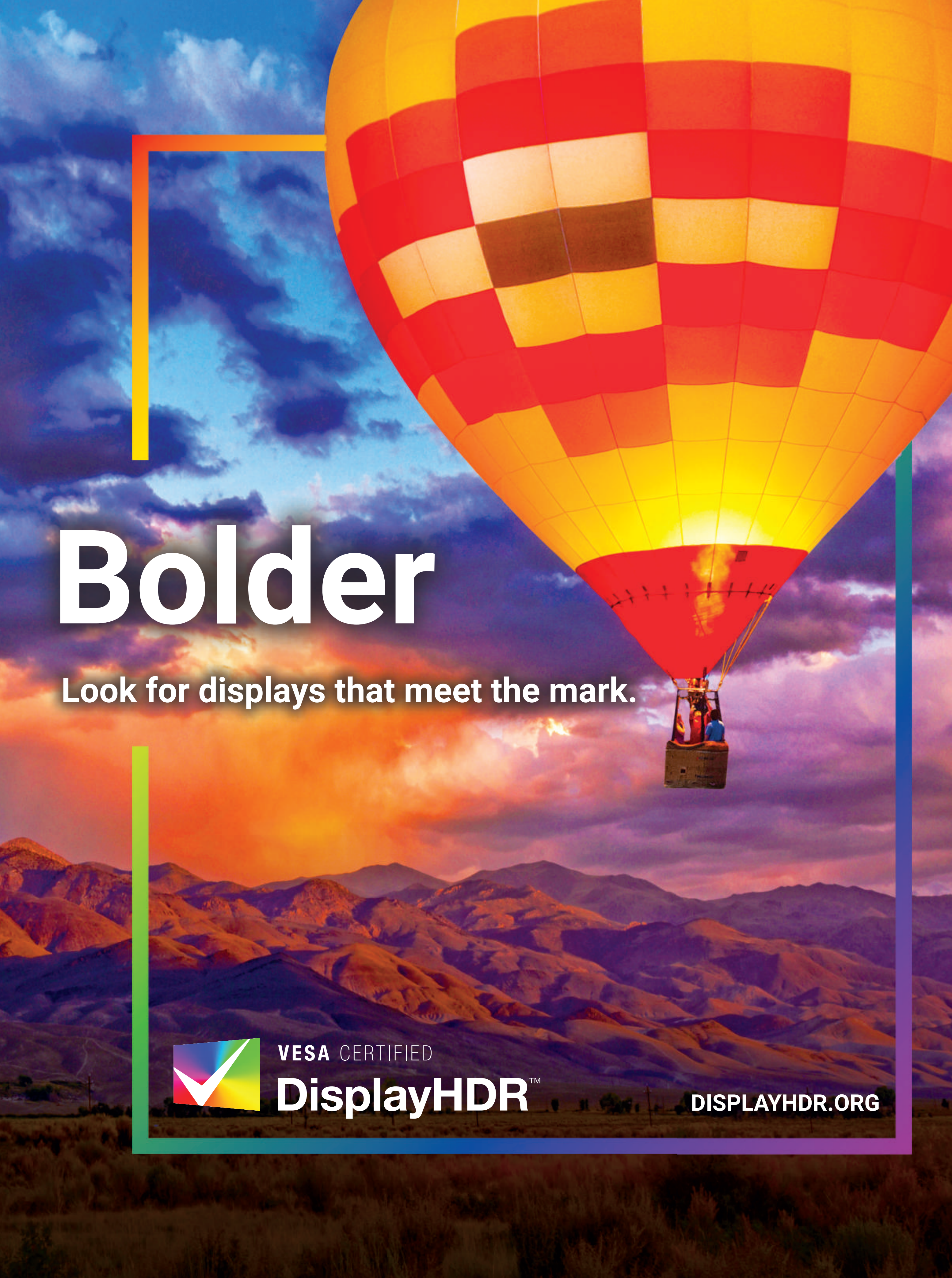
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