



The Standard of Excellence for Image and Picture Quality

- Home
- End User Products
- Professional Products
- Selection Guide
- Ordering Information
- Contact Us

Order

- Product Information
- End User Products
- Professional Products
- Complete Productline
- Ordering
- Ordering Information
- Volume Discounts
- Upgrades
- Order Online
- Order
- General Information
- Intro to DisplayMate
- Reviews + Awards
- Best Video Hardware
- Display Information
- DisplayMate on Twitter
- Evaluation Guides
- Mobile Displays
- HDTV Displays
- Special Information
- Printer Calibration
- Macs + Linux + Unix
- Consulting Services
- Customer Information
- Customer Support
- Join Our Mailing List
- Register Online
- Software License
- Contact Us
- Company Information
- About Us
- Contact Us
- Website
- Site Map
- Home Page
- Legal Terms of Use

iPhone X OLED Display Technology Shoot-Out

Dr. Raymond M. Soneira
President, DisplayMate Technologies Corporation

Copyright © 1990-2017 by DisplayMate Technologies Corporation. All Rights Reserved.
This article, or any part thereof, may not be copied, reproduced, mirrored, distributed or incorporated into any other work without the prior written permission of DisplayMate Technologies Corporation

Article Links: [Apple iPhone 7 LCD Display Technology Shoot-Out](#)

Article Links: [Samsung Galaxy Note8 OLED Display Technology Shoot-Out](#)

Article Links: [Display Color Gamuts Shoot-Out NTSC to Rec.2020](#)

Article Links: [Absolute Color Accuracy Display Technology Shoot-Out](#)

Article Links: [Watching Displays at Night](#)

Article Links: [Mobile Display Shoot-Out Article Series Overview and Home Page](#)

Article Links: [Display Technology Shoot-Out Article Series Overview and Home Page](#)



iPhone X

Introduction

The key element for a great Smartphone has always been a truly innovative and top performing display, and the best leading edge Smartphones have always flaunted their super high tech displays. It is the display performance that determines how good and how beautiful everything on the Smartphone looks, including the camera photos and all of your Apps, and also how readable and how usable the screen is in high ambient lighting. The Display is the crown jewel of the Smartphone!

The iPhone X OLED is the most anticipated display in the history of the world!!

The overwhelming majority of all existing displays, from Smartphones to TVs, including all of the earlier iPhones, have [Liquid Crystal Displays, LCDs](#), which produce an image by varying the light transmission from a light source behind the display.

But starting in 2010, displays using a different technology called [Organic Light Emitting Diodes, OLEDs](#), that directly emit light began appearing in Smartphones. While initially they couldn't match the high image quality produced by LCDs, they rapidly improved in display performance as shown in the extensive lab tests and measurements in my [Display Technology Shoot-Out](#) article series.

Within a few years it became obvious that OLEDs would soon outperform LCDs, particularly in Smartphones. So the big question was when, not if, manufacturers would begin switching to OLED displays. For Apple, the transition was particularly difficult because it needs hundreds of millions of OLED displays, and Samsung Display was the only company manufacturing them in high volume.

By 2015 the switch to OLED iPhones became the single hottest topic in large numbers of technology publications, and then came the business and Wall Street analysts that piled on as well. By 2017 it was a deafening roar as it became obvious that Apple would launch an OLED iPhone this year... and it's the iPhone X...

Switching from LCDs to OLEDs is a major engineering and manufacturing challenge, so I was eager to test and evaluate the new OLED iPhone X.

The result: Apple has produced an impressive Smartphone display with excellent performance and accuracy, which we cover in extensive detail below. What makes the iPhone X the [Best Smartphone Display](#) is the impressive Precision Display Calibration Apple developed, which transforms the OLED hardware into a superbly accurate, high performance, and gorgeous display, with close to Text Book Perfect Calibration and Performance!!

In this article we lab test, measure, analyze, and evaluate in depth the display on the iPhone X. This is an independent scientific objective lab test and analysis of OLED displays written for consumers and journalists. It is the latest edition in our seven year article series that has lab tested, tracked and analyzed the development of mobile OLED displays and display technology, from its early beginnings in 2010, when OLED displays started out in last place, into a rapidly improving and evolving display technology that now has a commanding first place lead and continues pushing ahead aggressively.

We'll cover all of these display performance topics and much more, with in-depth comprehensive display tests, measurements, and analysis that you will find nowhere else.

The Shift from LCD to OLED Displays

LCDs are a great cutting edge high performance display technology for Tablets to TVs, but for small handheld Smartphones, OLED displays provide a number of significant advantages over LCDs including: being much thinner, much lighter, without needing a bezel providing a rimless edge-to-edge design. They can be made flexible and into curved screens, plus they have a very fast response time, better viewing angles, and an always-on display mode. Many of the OLED performance advantages result from the fact that every single sub-pixel in an OLED display is independently directly electrically powered to emit light, so only the active image sub-pixels draw power based on their individual brightness levels. OLEDs can also provide better color accuracy, image contrast accuracy, and screen uniformity because of variations in the Backlights of LCDs.

As the result of their very versatile power management capabilities, OLEDs are not only more power efficient than LCDs for most image content, but they now deliver much higher peak Brightness than LCDs because the maximum power can be delivered to just the sub-pixels that are needed for producing the current image. However, for mostly all white screen content LCDs are likely to remain brighter and more power efficient for a while.

OLED displays are also manufactured on flexible substrates that can bend, which allows the screens to be curved and rounded and provides a number of innovative new screen geometries. The main production and availability issue for the next several years will be that the demand for OLED displays will significantly exceed the manufacturing capacity as we discuss in [Flagship 2017 OLED Smartphones](#).

Article Overview

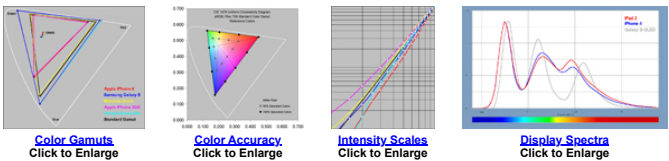
This article has the following major sections:

- [Highlights and Performance Results](#)
- [iPhone X Conclusions](#)
- [Improving the Next Generation of Mobile Displays](#)
- [Lab Measurements and Comparison Table](#)

The Display Shoot-Out

To examine the performance of the new [iPhone X OLED Display](#) we ran our in-depth series of [Mobile Display Technology Shoot-Out](#) Lab tests and measurements in order to determine how the latest OLED displays have improved. We take display quality very seriously and provide in-depth objective analysis based on detailed laboratory tests and measurements and extensive viewing tests with both test patterns, test images and test photos. To see how far OLED and LCD mobile displays have progressed in just six years see our [2010 Smartphone Display Shoot-Out](#), and for a real history lesson see our original [2006 Smartphone Display Shoot-Out](#).

Apple provided DisplayMate Technologies with a retail unit of the iPhone X so that we could perform our well known objective and comprehensive DisplayMate Lab tests, measurements, and analysis, explaining in-depth the new display performance results for consumers, reviewers, and journalists as early as possible.



Highlights and Performance Results

In this section we review and explain the principal results from the extensive DisplayMate Lab Tests and Measurements covered in the [Display Shoot-Out Comparison Table](#) under the following categories: [Display Specifications](#), [Overall Assessments](#), [Screen Reflections](#), [Brightness and Contrast](#), [Colors and Intensities](#), [Viewing Angles](#), [OLED Spectra](#), [Display Power](#).

Main Topics Covered

This [Highlights and Performance Results](#) section has detailed information and analysis on the iPhone X display for the main topics listed below. You can skip this section and go directly to the [iPhone X Conclusions](#).

- [Larger Full Screen Display](#)
- [2.5K Higher Resolution Display](#)
- [Industry Standard Color Gamuts](#)
- [Automatic Color Management](#)
- [Record Absolute Color Accuracy](#)
- [Record High Screen Brightness](#)
- [High Dynamic Range Mobile HDR](#)
- [Night Shift mode for Better Night Viewing](#)
- [Diamond Sub-Pixels](#)
- [Display Power Efficiency](#)
- [Viewing Angle Performance and Viewing Tests](#)
- [Display Related Enhancements](#)

• Larger Full Screen Display with a New Aspect Ratio of 19.5 : 9

The iPhone X has a new larger 5.85 inch full screen display that fills almost the entire front face of the phone from edge-to-edge. The display also has a new form factor with a taller height to width [Aspect Ratio](#) of 19.5 : 9 = 2.17, which is 22% larger than the 16 : 9 = 1.78 on most Smartphones (and widescreen TVs) because the display now has the same overall shape as the entire phone. It is taller in Portrait mode and wider in Landscape mode. This provides extra space for Notifications and for displaying multiple Apps and content simultaneously on-screen side-by-side.

The very top of the screen has a black 0.2" high (5 mm) cutout area from the display that holds the front facing camera, ambient light and proximity sensors, and the ear speaker. It's noticeable but easy to get used to because it only takes up 2% of the total screen area.

• 2.5K Higher Resolution Full HD+ 2436x1125 Display with 458 pixels per inch

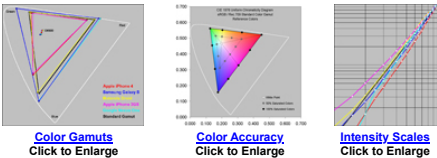
As a result of its larger display size and larger Aspect Ratio, the iPhone X has a new 2.5K Higher Resolution Full HD+ display with 2436x1125 pixels and 458 pixels per inch, with 2.7 Mega Pixels, 32% more than an HDTV. The display has [Diamond Sub-Pixels](#) (see below) and [Sub-Pixel Rendering](#) with 458 pixels per inch (ppi), providing significantly higher image sharpness than can be resolved with normal 20/20 Vision at the typical viewing distances of 12 inches or more for Smartphones, so the display appears perfectly sharp. As a result, for Smartphones it is absolutely pointless to further increase the display resolution and pixels per inch (ppi) up to 4K (3940x2160 pixels) for a silly marketing wild goose chase into the stratosphere, with no visual benefit for humans!

• Industry Standard Color Gamuts

The iPhone X supports the two most important [Industry Standard Color Gamuts](#): the sRGB / Rec.709 Color Gamut that is used for most current consumer content, and the new [Wide DCI-P3 Color Gamut](#) that is used in 4K Ultra HD TVs. The DCI-P3 Gamut is 26 percent larger than the sRGB / Rec.709 Gamut. But Automatic Color Management provides many more Gamuts...

• Automatic Color Management

Most Smartphones and Tablets generally provide only one to up to several fixed Color Gamuts. The iPhone X has [Automatic Color Management](#) that automatically switches to the proper Color Gamut for any displayed image content within the Wide DCI-P3 Color Space that has an ICC Profile, so images automatically appear with the correct colors, neither over-saturated or under-saturated. Color Management with multiple and varying Color Gamuts are a very useful and important state-of-the-art capability that all manufacturers will need to provide in the future.



• Record Absolute Color Accuracy

Delivering great color with high Absolute Color Accuracy is incredibly difficult because everything on the display has to be done just right. In order to deliver accurate image colors, a display needs to closely match the standard Color Gamut that was used for producing the content being viewed – not more and not less. In addition the display also needs an accurate (pure logarithmic power-law) [Intensity Scale](#), and an accurate [White Point](#).

Since the iPhone X supports two Standard Color Gamuts it needs to also implement Color Management in order to get the second smaller sRGB / Rec.709 Gamut to also appear correctly, which is generated from the wider native DCI-P3. Each iPhone X display is individually calibrated at the factory for both color and contrast accuracy.

The [Absolute Color Accuracy](#) of the iPhone X is [Truly Impressive](#) as shown in these [Figures](#). It has an Absolute Color Accuracy of 1.0 JNCD for the sRGB / Rec.709 Color Gamut that is used for most current consumer content, and 0.9 JNCD for the Wider DCI-P3 Color Gamut that is used for 4K UHD TVs and Digital Cinema. It is the most color accurate display that we have ever measured. It is [Visually Indistinguishable From Perfect](#), and is very likely considerably better than any mobile display, monitor, TV or UHD TV that you have.

See this [Figure](#) for an explanation and visual definition of [Just Noticeable Color Difference JNCD](#) and the [Color Accuracy Plots](#) with 41 Reference Colors showing the measured display Color Errors. See the [Color Accuracy](#) section and the [Color Accuracy Plots](#) for measurements and details, and also this regarding lots of [Bogus Color Accuracy Measurements](#).

• Record High Screen Brightness and Performance in High Ambient Lighting

Mobile displays are often used under relatively bright ambient lighting, which washes out the image color saturation and contrast, reducing picture quality and making it harder to view or read the screen. To be usable in high ambient light a display needs a dual combination of high [Screen Brightness](#) and low [Screen Reflectance](#) – the iPhone X has both. This is extremely important for screen readability, picture quality, and color accuracy in ambient light.

The iPhone X has a record high [Full Screen Brightness](#) for OLED Smartphones of 634 nits, which improves screen visibility in high Ambient Light. The Samsung Galaxy Note8 can produce up to 1,240 nits, but only for small portions of the screen area (Low Average Picture Levels) – for Full Screen

Brightness the Note8 can produce up to 423 nits with Manual Brightness and 560 nits with Automatic Brightness only in High Ambient Light. For small portions of the screen area the iPhone X can produce up to **809 nits** (Low Average Picture Levels). On its [Home Screen](#) the iPhone X produces an impressively bright **726 nits**. See the [Screen Brightness](#) section for the measurements and details.

The measured iPhone X [Screen Reflectance](#) is **4.5 percent**, close to the lowest that we have ever measured for a Smartphone. Our [Contrast Rating for High Ambient Light](#) quantitatively measures screen visibility and image contrast under bright Ambient Lighting – the higher the better. As a result of its high Brightness and low Reflectance, the iPhone X has a Contrast Rating for High Ambient Light that ranges from **141 to 180**, among the highest that we have ever measured for a Smartphone. See the [Screen Reflectance](#) section for the measurements and details.

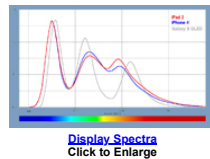
- **HDR High Dynamic Range Mobile HDR Premium Display**

The iPhone X provides [Mobile HDR](#), which allows it to play 4K High Dynamic Range content made for 4K UHD TVs. [High Dynamic Range](#) (HDR) is the newest performance enhancement feature developed for the latest 4K Ultra HD TVs. HDR provides expanded the Color, Contrast, and Brightness of video content. In order to provide HDR, the iPhone X has the required Digital Cinema DCI-P3 Wide Color Gamut, plus perfect Blacks and an Infinite Contrast Ratio from its OLED display

- **Night Shift Mode for Better Night Viewing**

The [Night Shift](#) mode on the iPhone X is designed to change the color balance of the display in order to reduce the amount of Blue light produced by the display, which some recent research indicates can affect how well users sleep afterwards. In a separate [article](#) we explain and analyze the Blue Light issue for displays. The iPhone X includes a user adjustable slider to vary the amount of Blue light produced by the display, and a timer that allows the Night Shift to be turned on and off automatically every day. The measured variation in the display light spectrum with the adjustable Night Shift slider is shown in this [Figure](#) and below.

As the Night Shift slider setting is increased, the amount of Blue light emitted by the display decreases. When that happens, White and all screen colors take on an increasing yellowish tint and color cast. At the [Middle setting](#) the measured White Color Temperature decreases to **4,200K**, and at the [Maximum setting](#) it decreases to **2,800K**, the Color Temperature of traditional incandescent lighting, which is yellowish. With Night Shift at its Maximum setting, the measured Blue Light component from the iPhone X is reduced by 80 percent. Turning down the screen Brightness will further decrease the amount of Blue Light. The measured display spectra for several of the [Night Shift](#) settings are included in this [Figure](#) and below.



- **True Tone Viewing Mode**

The [True Tone](#) viewing mode automatically changes the White Point and color balance of the display based on real-time measurements of the ambient light falling on the screen. The idea is to make the display behave more like paper reflecting ambient light and taking on its color. It is implemented with an Ambient Light sensor that measures the Color of the ambient light in addition to its Brightness.

- **Super Dim Setting**

The iPhone X also has a [Super Dim Setting](#) that allows the Maximum Screen Brightness to be set all the way down to just **2 cd/m²** (nits) using the Brightness Slider. This is perfect for night use on a bedside table, and useful for working comfortably without eye strain or bothering others in very dark environments, or affecting the eye's dark adaptation, such as when using a telescope. The display still provides full 24-bit color and the picture quality remains excellent.

- **Diamond Sub-Pixels**

A [high resolution screen shot](#) obtained with an optical microscope camera shows a Diamond shaped layout for the Sub-Pixels on the iPhone X. This Diamond Sub-Pixel layout is used on many OLED displays. On the iPhone X the resulting Sub-Pixel fill factor is much higher than other OLEDs, which is a key factor in providing the much higher full Screen Peak Luminance of over 625 nits.

The Red, Green, and Blue sub-pixels have very different sizes – Blue is by far the largest because it has the lowest light emission efficiency, and Green is by far the smallest because it has the highest efficiency. The alternating Red and Blue sub-pixel arrangement leads to a 45 degree diagonal symmetry in the sub-pixel layout. This allows vertical, horizontal, and particularly diagonal line segments and vectors to be drawn with reduced aliasing and artifacts. In order to maximize the sub-pixel packing and achieve the highest possible pixels per inch (ppi), that leads to a Diamond rather than Square or Striped arrangement of the Sub-Pixels. It's a form of high-tech display art...

- **Display Power Efficiency**

While LCDs remain more power efficient for images with mostly full screen white content (like all text screens on a white background, for example), OLEDs are more power efficient for typical mixed image content because they are emissive displays so their power varies with the Average Picture Level (average Brightness) of the image content over the entire screen. For OLEDs, Black pixels and sub-pixels don't use any power so screens with Black or dark backgrounds are very power efficient for OLEDs. For LCDs the display power is fixed and independent of image content. Currently, OLED displays are more power efficient than LCDs for Average Pictures Levels of 65 percent or less, and LCDs are more power efficient for Average Picture Levels above 65 percent. Since both technologies are continuing to improve their power efficiencies, the crossover will continue to change with time. See the [Display Power](#) section for the measurements and details.

- **Viewing Angle Performance**

While Smartphones are primarily single viewer devices, the variation in display performance with viewing angle is still very important because single viewers frequently hold the display at a variety of viewing angles. The angle is often up to 30 degrees, more if it is resting on a table or desk. While LCDs typically experience a 55 percent or greater decrease in Brightness at a 30 degree Viewing Angle, the OLED iPhone X display shows a much smaller 22 percent decrease in Brightness at 30 degrees. This also applies to multiple side-by-side viewers as well, and is a significant advantage of OLED displays. The Color Shifts with Viewing Angle are also relatively small. See the [Viewing Angles](#) section for the measurements and details.

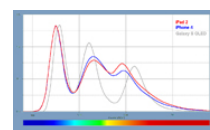
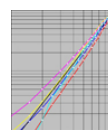
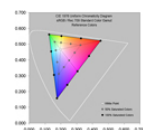
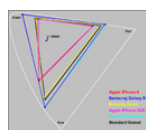
- **Viewing Tests**

The iPhone X provides very nice, pleasing and very accurate colors and picture quality. Although the Image Contrast is slightly too high (due to a slightly too steep Intensity Scale), the very challenging set of DisplayMate Test and Calibration Photos that we use to evaluate picture quality looked **absolutely stunning and Beautiful**, even to my experienced hyper-critical eyes.

The iPhone X excels due to its record Absolute Color Accuracy (1.0 JNCD), which is [Visually Indistinguishable from Perfect](#), and is very likely considerably better than any mobile display, monitor, TV or UHD TV that you have. So photos, videos, and online content and merchandise will appear correct and beautiful. See the [Color Accuracy Figures](#) and the [Colors and Intensities](#) section for quantitative details.

- **Display Related Enhancements**

- The iPhone X is IP67 water resistant in up to 1 meter (3 feet) of water for up to half an hour, which means you can comfortably view the display in typical wet indoor and outdoor conditions – even carefully use it in a tub or shower, and it should be fine if you accidentally drop it in a sink or toilet.
- The iPhone X can be used with Polarized Sunglasses in both the Portrait and Landscape orientations unlike many LCDs, which generally work in only one of the two orientations.
- The iPhone X Cover Glass is 50% stronger compared to iPhone 7 and iPhone 7 Plus, which provides higher resistance to breakage.



iPhone X Conclusions: A Very Impressive Smartphone Display...

The primary goal of this [Display Technology Shoot-Out article series](#) has always been to publicize and promote display excellence so that consumers, journalists and even manufacturers are aware of and appreciate the very best in displays and display technology. We point out which manufactures and display technologies are leading and advancing the state-of-the-art for displays by performing comprehensive and objective scientific Lab tests and measurements together with in-depth analysis. We point out who is leading, who is behind, who is improving, and sometimes (unfortunately) who is back pedaling... all based solely on the extensive objective careful Lab measurements that we also publish, so that everyone can judge the data for themselves as well...

The Best Smartphone Display

- The iPhone X is the most innovative and high performance Smartphone display that we have ever tested.
- First we need to congratulate Samsung Display for developing and manufacturing the outstanding OLED display hardware in the iPhone X.
- But what makes the iPhone X the **Best Smartphone Display** is the impressive Precision Display Calibration that Apple developed that transforms the OLED hardware into a superbly accurate, high performance, and gorgeous display!!

See the [Display Shoot-Out Comparison Table](#) section below for the complete DisplayMate Lab measurements and test details.

See the [Highlights and Performance Results](#) section above for a detailed overview with expanded discussions and explanations.

See the [Display Assessments](#) section for the evaluation details.

The iPhone X has the following enhanced state-of-the-art display performance functions and features:

- A state-of-the-art **OLED display** that is manufactured on a flexible plastic substrate. While the OLED display itself is flexible, the screen remains rigid under an outer hard cover glass.
- A **2.5K High Resolution 2436 x 1125 Full HD+ Display** with **458 pixels per inch**, and **Diamond Sub-Pixels** with Sub-Pixel Rendering for enhanced sharpness and higher Peak Brightness.
- A radical new **Full Screen** design with a larger **5.85 inch OLED display** that fills almost the entire front face of the iPhone X from edge-to-edge, providing a significantly larger display for the same phone size.
- A new display form factor with a taller height to width **Aspect Ratio of 19.5 : 9 = 2.17**, which is 22% larger than the 16 : 9 = 1.78 on most Smartphones (and widescreen TVs) because the display now has the same overall shape as the entire phone. It is taller in Portrait mode and wider in Landscape mode.
- A record high **Full Screen Brightness** for OLED Smartphones of **634 nits**, which improves screen visibility in high Ambient Light. The Samsung Galaxy Note8 can produce up to 1,240 nits, but only for small portions of the screen area (Low Average Picture Levels) – for Full Screen the Note8 can produce up to 423 nits with Manual Brightness and 560 nits with Automatic Brightness only in High Ambient Light. For small portions of the screen area the iPhone X can produce up to 809 nits (Low Average Picture Levels). On its **Home Screen** the iPhone X produces an impressively bright **726 nits**.
- The **Highest Absolute Color Accuracy** of any display we have ever tested, **0.9 JNCD** (from Smartphones to TVs) based on our extensive [Lab Measurements](#), which is **Visually Indistinguishable From Perfect**.
- **2 Industry Standard Color Gamuts**: the **sRGB / Rec.709 Color Gamut** that is used for most current consumer content, and the new **Wide DCI-P3 Color Gamut** that is used in 4K Ultra HD TVs. The DCI-P3 Gamut is 26 percent larger than the sRGB / Rec.709 Gamut.
- **Automatic Color Management** that automatically switches to the proper Color Gamut for any displayed image content within the Wide DCI-P3 Color Space that has an ICC Profile, so images automatically appear with the correct colors, neither being over-saturated or under-saturated.
- The iPhone X supports **Mobile HDR**, which allows the iPhone X to play 4K High Dynamic Range content produced for **4K UHD TVs**.
- A **Night Shift Mode** that allows the user to adjust and reduce the amount of Blue Light from the display for better night viewing and improved sleep.
- A **True Tone** viewing mode that automatically changes the White Point and color balance of the display based on real-time measurements of the ambient light falling on the screen to make the display behave more like paper reflecting ambient light and taking on its color.
- **Small Color Shifts and Brightness Shifts** with [Viewing Angle](#).
- The **iPhone X** can be used with **Polarized Sunglasses** in both the Portrait and Landscape orientations unlike many LCDs, which generally work in only one of the two orientations.

The iPhone X matches or sets new Smartphone display performance records for:

- Highest **Absolute Color Accuracy** for any display (0.9 JNCD) which is **Visually Indistinguishable From Perfect**.
- Highest **Full Screen Brightness for OLED Smartphones** (634 nits).
- Highest **Full Screen Contrast Rating in Ambient Light** (141).
- Highest **Contrast Ratio** (Infinite).
- Lowest **Screen Reflectance** (4.5 percent).
- Smallest Brightness Variation with [Viewing Angle](#) (22 percent).

The Best Smartphone Display

The **iPhone X** delivers uniformly consistent all around Top Tier display performance and receives **All Green (Very Good to Excellent) Ratings** in all of the DisplayMate Lab test and measurement Categories (except for a single Yellow in Brightness Variation with Average Picture Level that applies to all OLED displays). See the [Display Shoot-Out Comparison Table](#) below for all of the measurements and details, and the [Highlights and Performance Results](#) section above for expanded discussions and explanations, and the [Display Assessments](#) section for the evaluation details.

Based on our extensive lab tests and measurements the iPhone X becomes the Best Performing Smartphone Display that we have ever tested, earning DisplayMate's highest ever A+ grade. The iPhone X is an impressive display with close to Text Book Perfect Calibration and Performance!!

Improving the Next Generation of Mobile Displays

The **iPhone X** has a very high resolution 2.5K 2436x1125 pixel display with 458 pixels per inch (ppi) producing images that look perfectly sharp with normal 20/20 Vision under all normal viewing conditions, which always includes some ambient light that always lowers the visible image contrast and perceived image sharpness (Modulation Transfer MTF). **Note that displays are almost never viewed in absolute darkness under perfect viewing conditions with ideal image content.** Some clueless reviewers have been pining for 4K 3840x2160 Smartphones, which would require more than triple the pixels, memory, and processing power of the 2436x1125 display on the iPhone X, but there would be **no visual benefit for humans! As a result, it is absolutely pointless to further increase the display resolution and pixels per inch (ppi) for a marketing wild goose chase into the stratosphere, with no visual benefit for humans!**

With screen size and resolution already functionally maxed out, manufacturers should instead dedicate their efforts and resources into improving real world display performance in ambient light by using advanced technology to restore and compensate for the loss of color gamut, color saturation, and image contrast due to ambient light, something that every consumer will benefit from, and will also immediately notice and appreciate – providing a true sales and marketing advantage...

The most important improvements for OLED and LCD mobile displays will come from improving their image and picture quality and screen readability in real world ambient light, which washes out the screen images, resulting in reduced image contrast, color saturation, and color accuracy. The key will be in lowering the **Screen Reflectance** and implementing **Dynamic Color Management** with automatic real-time modification of the display's native Color Gamut and **Dynamic Intensity Scales** based on the measured Ambient Light level in order to have them compensate for the reflected light glare and image wash out that causes a loss of color saturation and image contrast from ambient light as discussed in our [Innovative Displays and Display Technology](#), and [SID Display Technology Shoot-Out](#) articles.

In our [High Picture Quality in Real World Ambient Lighting](#) article we demonstrate that a major advantage of using **Dynamic Color Management** and **Dynamic Intensity Scales** rather than the current brute force method of just increasing the Picture Brightness in ambient light is that it can produce the same vibrant on-screen colors in ambient light with 75 percent less display power up through 2,000 lux, which is very important for TV energy efficiency, and also very important for Smartphones because they depend on limited battery power.

The displays, technologies, and manufacturers that succeed in implementing this new real world high ambient light performance strategy will take the lead in the next generations of mobile displays... Follow [DisplayMate on Twitter](#) to learn about these developments and our upcoming display technology coverage.

DisplayMate Display Optimization Technology

All Smartphone, Tablet, Monitor and TV displays can be significantly improved using DisplayMate's proprietary very advanced scientific analysis and mathematical display modeling and optimization of the display hardware, factory calibration, and driver parameters. We help manufacturers with expert display procurement, prototype development, display performance improvement and optimization, testing displays to meet contract specifications, and

production quality control so that they don't make mistakes similar to those that are exposed in our public Display Technology Shoot-Out series for consumers. This article is a lite version of our advanced scientific analysis – before the benefits of our [DisplayMate Display Optimization Technology](#), which can correct or improve all of these issues. If you are a display or product manufacturer and want to significantly improve display performance for a competitive advantage then [Contact DisplayMate Technologies](#).



iPhone X

Display Shoot-Out Comparison Table

Below we examine in-depth the OLED display on the Apple iPhone X based on objective Lab measurement data and criteria in the following sections: [Display Specifications](#), [Overall Assessments](#), [Screen Reflections](#), [Brightness and Contrast](#), [Colors and Intensities](#), [Viewing Angles](#), [OLED Spectra](#), [Display Power](#).

For additional background information see this earlier article covering the [Flagship OLED 2017 Smartphones](#).

Detailed Test and Measurement Comparisons between the iPhone X, the Galaxy Note8, and the iPhone 7 Displays

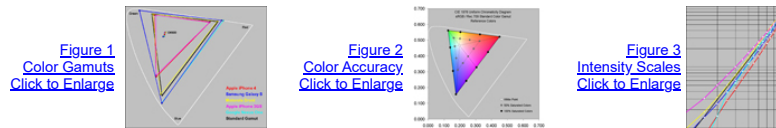
You can directly compare the data and measurement results for the iPhone X with the Galaxy Note8 and iPhone 7 displays in detail by using a Tabbed web browser with our comprehensive Lab measurements and analysis for each of the displays. For each Tab click on a Link below. The entries are mostly identical with only minor formatting differences, so it is easy to make detailed side-by-side comparisons by simply clicking through the Tabs.

- [Apple iPhone X Lab Measurements Comparison Table](#)
- [Samsung Galaxy Note8 Lab Measurements Comparison Table](#)
- [Apple iPhone 7 Lab Measurements Comparison Table](#)

For comparisons with the other leading Smartphone, Tablet, and Smart Watch displays see our [Mobile Display Technology Shoot-Out](#) series.

Categories	Apple iPhone X		Comments
Display Technology	5.85 inch Screen Diagonal Excluding the Rounded Corners OLED Display with Diamond Sub-Pixels		Organic Light Emitting Diode Diamond Sub-Pixels with Diagonal Symmetry.
Screen Shape	19.5 : 9 = 2.17 New Higher Aspect Ratio Most Smartphones and Widescreen TVs have 16 : 9 = 1.78		Height to Width Aspect Ratio iPhone X display screen is 22% longer than most Smartphones and widescreen 16:9 TV content.
Screen Size	2.46 x 5.32 inches		Display Width and Height in inches.
Screen Area	12.8 Square Inches Subtracting the Top Slot area but not the Rounded Corners		A better measure of size than the diagonal length.
Supported Color Gamuts	Wide Gamut – DCI-P3 Digital Cinema Color Gamut Standard Gamut – sRGB / Rec.709 Standard Color Gamut		The iPhone X supports 2 Color Gamuts including the new wider DCI-P3 Color Gamut that is used in the 4K TV content.
Display Resolution	2436 x 1125 pixels 2.5K Full HD+		Screen Pixel Resolution. Quad HD can display four 1280x720 HD images.
Total Number of Pixels	2.7 Mega Pixels		Total Number of Pixels.
Pixels Per Inch	458 PPI with Diamond Sub-Pixels Excellent		Sharpness depends on the viewing distance and PPI. See this on the visual acuity for a true Retina Display.
Sub-Pixels Per Inch	Red 324 SPPI Green 458 SPPI Blue 324 SPPI		Diamond Sub-Pixel displays have only half the number of Red and Blue Sub-Pixels as RGB Stripe displays.
Total Number of Sub-Pixels	Red 1.4 Million Sub-Pixels Green 2.7 Million Sub-Pixels Blue 1.4 Million Sub-Pixels		Number of Mega Sub-Pixels for Red, Green, Blue. Diamond Sub-Pixel displays have only half the number of Red and Blue Sub-Pixels as RGB Stripe displays. At High PPI this is generally not visible due to the use of Sub-Pixel Rendering .
20/20 Vision Distance where Pixels or Sub-Pixels are Not Resolved	7.5 inches for White and Green Sub-Pixels with 20/20 Vision 10.6 inches for Red and Blue Sub-Pixels with 20/20 Vision		For 20/20 Vision the minimum Viewing Distance where the screen appears perfectly sharp to the eye.
Display Sharpness at Typical Viewing Distances	iPhone X Display appears Perfectly Sharp Pixels are not Resolved with 20/20 Vision at Typical Viewing Distances of 12 to 18 inches		The Typical Viewing Distances for this screen size are in the range of 12 to 18 inches. Also note that eye's resolution is much lower for Red and Blue color content than White and Green.
Appears Perfectly Sharp at Typical Viewing Distances	Yes		Typical Viewing Distances are 12 to 18 inches for this screen size.
Photo Viewer Color Depth	Full 24-bit Color No Dithering Visible 256 Intensity Levels		Some Smartphones and Tablets still have some form of 16-bit color depth in the Gallery Viewer. The Apple iPhone X does not have this issue.
Overall Assessments This section summarizes the results for all of the extensive Lab Measurements and Viewing Tests performed on the display. See Screen Reflections , Brightness and Contrast , Colors and Intensities , Viewing Angles , OLED Spectra , Display Power . The iPhone X automatically switches to the appropriate calibrated Gamut for the current on-screen content. The DCI-P3 Digital Cinema Gamut is used in Ultra HD TVs, and other advanced imaging applications. The sRGB / Rec.709 Gamut is used for most current consumer photo, video, web, and computer content.			
Categories	Wide Gamut DCI-P3 Digital Cinema	Standard Gamut sRGB / Rec.709 Content	Comments
Viewing Tests in Subdued Ambient Lighting	Excellent Images Photos and Videos have Excellent Color and Accurate Contrast Accurate Wide Gamut	Excellent Images Photos and Videos have Excellent Color and Accurate Contrast Accurate Standard Gamut	The Viewing Tests examine the accuracy of photographic images by comparing the displays to an calibrated studio monitor and TV.
Variation with Viewing Angle Colors and Brightness See Viewing Angles	Small Color Shifts with Viewing Angle Small Brightness Shifts with Viewing Angle	Small Color Shifts with Viewing Angle Small Brightness Shifts with Viewing Angle	The iPhone X display has a relatively small decrease in Brightness with Viewing Angle and relatively small Color Shifts with Viewing Angle. See the Viewing Angles section for details.
Overall Display Assessment Lab Tests and Measurements	Excellent OLED Display Accurate Wide Gamut	Excellent OLED Display Accurate Standard Gamut	The iPhone X OLED Display performed very well in the Lab Tests and Measurements.

Absolute Color Accuracy Measured over Entire Gamut See Figure 2 and Colors	Excellent Color Accuracy Accurate Wide Gamut Color Errors are Small	Excellent Color Accuracy Accurate Standard Gamut Color Errors are Small	Absolute Color Accuracy is measured with a Spectroradiometer for 41 Reference Colors uniformly distributed within the entire Color Gamut. See Figure 2 and Colors for details.
Image Contrast Accuracy See Figure 3 and Contrast	Very Good Contrast Accuracy Image Contrast Slightly Too High	Very Good Contrast Accuracy Image Contrast Slightly Too High	The Image Contrast Accuracy is determined by measuring the Log Intensity Scale and Gamma. See Figure 3 and Contrast for details.
Performance in Ambient Light Display Brightness Screen Reflectance Contrast Rating See Brightness and Contrast See Screen Reflections	High Display Brightness Very Low Reflectance High Contrast Rating for Ambient Light	High Display Brightness Very Low Reflectance High Contrast Rating for Ambient Light	Smartphones are seldom used in the dark. Screen Brightness and Reflectance determine the Contrast Rating for High Ambient Light. See the Brightness and Contrast section for details. See the Screen Reflections section for details.
Overall Display Calibration Image and Picture Quality Lab Tests and Viewing Tests	Excellent Calibration Accurate Wide Gamut	Excellent Calibration Accurate Standard Gamut	iPhone X display delivers accurately calibrated colors and images for both the Wide Gamut and Standard Gamut.
Overall Display Grade Overall Assessment	Overall iPhone X Display Grade is Excellent A+ The Best Performing Smartphone Display that we have ever tested!! Impressive with close to Text Book Perfect Calibration and Performance. Accurate Wide Gamut For Viewing 4K UHD TV DCI-P3 Cinema Content Accurate Standard Gamut For Viewing Most Content Photo Video Movie Web		The iPhone X display delivers excellent image quality, has both Wide Color Gamut and Standard Color Gamut modes, with high Screen Brightness and low Reflectance, has good Viewing Angles, and is an all around top performing Smartphone display.
Categories	Wide Gamut DCI-P3 Digital Cinema	Standard Gamut sRGB / Rec.709 Content	Comments
Screen Reflections All display screens are mirrors good enough to use for personal grooming – but that is actually a very bad feature... We measured the light reflected from all directions and also direct mirror (specular) reflections, which are much more distracting and cause more eye strain. Many Smartphones still have greater than 10 percent reflections that make the screen much harder to read even in moderate ambient light levels, requiring ever higher brightness settings that waste precious battery power. Hopefully manufacturers will reduce the mirror reflections with anti-reflection coatings and matte or haze surface finishes. Our Lab Measurements include Average Reflectance for Ambient Light from All Directions and for Mirror Reflections . We use an Integrating Hemisphere and a highly collimated pencil light beam together with a Spectroradiometer. Note the Screen Reflectance is exactly the same for both Color Gamuts. The iPhone X has one of the lowest Screen Reflectance levels that we have ever measured for a Smartphone. These results are extremely important for screen readability, picture quality, and color accuracy in ambient light.			
Categories	iPhone X		Comments
Average Screen Reflection Light From All Directions	4.5 percent for Ambient Light Reflections Excellent		Measured using an Integrating Hemisphere and a Spectroradiometer. The lowest value we have ever measured for a Smartphone is 4.4 percent.
Mirror Reflections Percentage of Light Reflected	5.7 percent for Mirror Reflections Very Good		These are the most annoying types of Reflections. Measured using a Spectroradiometer and a narrow collimated pencil beam of light reflected off the screen. The lowest value we have ever measured for a Smartphone is 5.6 percent.
Brightness and Contrast The Contrast Ratio is the specification that gets the most attention, but it only applies for low ambient light, which is seldom the case for mobile displays. Much more important is the Contrast Rating , which indicates how easy it is to read the screen under high ambient lighting and depends on both the Maximum Brightness and the Screen Reflectance. The larger the better. The display's actual on-screen Contrast Ratio changes with the Ambient Light lux level and is proportional to the Contrast Rating .			
Categories	Wide Gamut DCI-P3 Digital Cinema	Standard Gamut sRGB / Rec.709 Content	Comments
Home Screen Peak Brightness Measured for White	Brightness 726 cd/m ² Excellent	Brightness 726 cd/m ² Excellent	The Peak Brightness for White on the Home Screen.
Measured Average Brightness 50% Average Picture Level	Brightness 700 cd/m ² Excellent	Brightness 695 cd/m ² Excellent	This is the Brightness for typical screen content that has a 50% Average Picture Level.
Measured Full Brightness 100% Full Screen White	Brightness 634 cd/m ² Excellent	Brightness 633 cd/m ² Excellent	This is the Brightness for a screen that is entirely all white with 100% Average Picture Level.
Measured Peak Brightness 1% Full Screen White	Brightness 804 cd/m ² Excellent	Brightness 809 cd/m ² Excellent	This is the Peak Brightness for a screen that has only a tiny 1% Average Picture Level.
Measured Auto Brightness in High Ambient Light with Automatic Brightness On	Auto Brightness in High Ambient Light 634 – 804 cd/m ² Excellent	Auto Brightness in High Ambient Light 633 – 809 cd/m ² Excellent	The Maximum Brightness is the same for both the Manual and Auto Brightness modes.
Low Ambient Light			
Lowest Peak Brightness Super Dim Setting Brightness Slider to Minimum	2 cd/m ² For Very Low Light	2 cd/m ² For Very Low Light	This is the Lowest Brightness with the Slider set to Minimum. This is useful for working in very dark environments. Picture Quality remains Excellent.
Black Brightness at 0 lux at Maximum Brightness Setting	0 cd/m ² Outstanding	0 cd/m ² Outstanding	Black Brightness is important for Low Ambient Light, which is seldom the case for mobile devices.
Contrast Ratio at 0 lux Relevant for Low Ambient Light	Infinite Outstanding	Infinite Outstanding	Only relevant for Low Ambient Light, which is seldom the case for mobile devices.
High Ambient Light			
Contrast Rating for High Ambient Light The Higher the Better for Screen Readability in High Ambient Light	141 – 179 Excellent	141 – 180 Excellent	Depends on the Screen Reflectance and Brightness. Defined as Maximum Brightness / Average Reflectance. The display's actual on-screen Contrast Ratio changes with the Ambient Light lux level and is proportional to the Contrast Rating.
Screen Readability in High Ambient Light	Excellent: A+	Excellent: A+	Indicates how easy it is to read the screen under High Ambient Lighting. Depends on both the Screen Reflectance and Brightness. See High Ambient Light Screen Shots
Colors and Intensities			

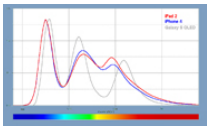


The Color Gamut, Intensity Scale, and White Point determine the quality and accuracy of all displayed images and all the image colors. Bigger is definitely Not Better because the display needs to match all the standards that were used when the content was produced. For LCDs a wider Color Gamut reduces the power efficiency and the Intensity Scale affects both image brightness and color mixture accuracy.

The iPhone X automatically switches to the appropriate Gamut for the current on-screen content.

Categories	Wide Gamut DCI-P3 Digital Cinema	Standard Gamut sRGB / Rec.709 Content	Comments
Color of White Color Temperature in degrees Measured in the dark at 0 lux See Figure 1	6,591 K 0.2 JNCD from D65 White Very Close to Standard Accurate Wide Gamut See Figure 1	6,597 K 0.2 JNCD from D65 White Very Close to Standard Accurate Standard Gamut See Figure 1	D65 with 6,500 K is the standard color of White for most Consumer Content and needed for accurate color reproduction of all images. JNCD is a <u>Just Noticeable Color Difference</u> . White Point accuracy is more critical than other colors. See Figure 1 for the plotted White Points. See Figure 2 for the definition of JNCD.
Color Gamut Measured in the dark at 0 lux See Figure 1	103 percent DCI-P3 Cinema Gamut Very Close to Standard Accurate Wide Gamut See Figure 1	103 percent sRGB / Rec.709 Gamut Very Close to Standard Accurate Standard Gamut See Figure 1	Most current consumer content uses sRGB / Rec.709. The new 4K UHD TVs and Digital Cinema use DCI-P3. A Wide Color Gamut is useful in High Ambient Light and for some applications. It can be used with Color Management to dynamically change the Gamut. See Figure 1
Color Accuracy			
Absolute Color Accuracy Average Color Error at 0 lux For 41 Reference Colors Just Noticeable Color Difference See Figure 2	Average Color Error From DCI-P3 $\Delta(u'v') = 0.0037$ 0.9 JNCD Excellent Color Accuracy Accurate Wide Gamut See Figure 2	Average Color Error From sRGB / Rec.709 $\Delta(u'v') = 0.0039$ 1.0 JNCD Excellent Color Accuracy Accurate Standard Gamut See Figure 2	JNCD is a <u>Just Noticeable Color Difference</u> . See Figure 2 for the definition of JNCD and for Accuracy Plots showing the measured Color Errors. Average Errors below 3.5 JNCD are Very Good. Average Errors 3.5 to 7.0 JNCD are Good. Average Errors above 7.0 JNCD are Poor.
Absolute Color Accuracy Largest Color Error at 0 lux For 41 Reference Colors Just Noticeable Color Difference See Figure 2	Largest Color Error From DCI-P3 $\Delta(u'v') = 0.0091$ 2.3 JNCD for Blue Very Good Accuracy Accurate Wide Gamut See Figure 2	Largest Color Error From sRGB / Rec.709 $\Delta(u'v') = 0.0096$ 2.4 JNCD for Blue Very Good Accuracy Accurate Standard Gamut See Figure 2	JNCD is a <u>Just Noticeable Color Difference</u> . See Figure 2 for the definition of JNCD and for Accuracy Plots showing the measured Color Errors. Largest Errors below 7.0 JNCD are Very Good. Largest Errors 7.0 to 14.0 JNCD are Good. Largest Errors above 14.0 JNCD are Poor. This is twice the limit for the Average Error.
Intensity Scale and Image Contrast Accuracy			
Dynamic Brightness Luminance Decrease with Average Picture Level APL	21 percent Decrease Good	22 percent Decrease Good	This is the percent Brightness decrease with APL Average Picture Level. Ideally should be 0 percent.
Intensity Scale and Image Contrast See Figure 3	Smooth and Straight Very Good Slightly Too Steep See Figure 3	Smooth and Straight Very Good Slightly Too Steep See Figure 3	The Intensity Scale controls image contrast needed for accurate Image Contrast and Color reproduction. See Figure 3
Gamma for the Intensity Scale Larger has more Image Contrast See Figure 3	Gamma 2.29 Very Good Gamma Slightly Too High	Gamma 2.29 Very Good Gamma Slightly Too High	Gamma is the log slope of the Intensity Scale. Gamma of 2.20 is the standard and needed for accurate Image Contrast and Color reproduction. See Figure 3
Image Contrast Accuracy	Very Good	Very Good	See Figure 3
Viewing Angles			
The variation of Brightness, Contrast, and Color with Viewing Angle is especially important for Smartphones because of their larger screen and multiple viewers. The typical manufacturer 176+ degree specification for LCD Viewing Angle is nonsense because that is where the Contrast Ratio falls to a miniscule 10. For most LCDs there are substantial degradations at less than ± 30 degrees, which is not an atypical Viewing Angle for Smartphones and Tablets. Note that the Viewing Angle performance is also very important for a single viewer because the Viewing Angle can vary significantly based on how the Smartphone is held. The Viewing Angle can be very large if resting on a table or desk. The Viewing Angle variations are essentially identical for both the Wide and Standard Gamuts.			
Categories	Wide Gamut DCI-P3 Digital Cinema	Standard Gamut sRGB / Rec.709 Content	Comments
Brightness Decrease at a 30 degree Viewing Angle	22 percent Decrease Small Decrease Very Good		Most screens become less bright when tilted. OLED decrease is due to optical absorption. LCD decrease is generally greater than 50 percent.
Contrast Ratio at 0 lux at a 30 degree Viewing Angle	Infinite Contrast Ratio Outstanding		A measure of screen readability when the screen is tilted under low ambient lighting.
White Point Color Shift at a 30 degree Viewing Angle	Small Color Shift $\Delta(u'v') = 0.0106$ 2.7 JNCD Very Good		JNCD is a <u>Just Noticeable Color Difference</u> . See Figure 2 for the definition of JNCD.
Primary Color Shifts Largest Color Shift for R,G,B at a 30 degree Viewing Angle	Largest Color Shift $\Delta(u'v') = 0.0249$ for Pure Blue 6.2 JNCD Very Good		JNCD is a <u>Just Noticeable Color Difference</u> . See Figure 2 for the definition of JNCD. Same Rating Scale as Absolute Color Accuracy.
Color Shifts for Color Mixtures at a 30 degree Viewing Angle Reference Brown (255, 128, 0)	Small Color Shift $\Delta(u'v') = 0.0071$ 1.8 JNCD Excellent		JNCD is a <u>Just Noticeable Color Difference</u> . Color Shifts for non-IPS LCDs are about 10 JNCD. Reference Brown is a good indicator of color shifts with angle because of unequal drive levels and roughly equal luminance contributions from Red and Green. See Figure 2 for the definition of JNCD.
Display Spectra			
The Display Spectra for the iPhone X including the Night Shift mode are measured in Figure 4 below. The Night Shift mode is designed to change the color balance of the display in order to reduce the amount of Blue Light produced by the display, which some recent research indicates can affect how well users sleep afterwards.			

Figure 4
Display Spectra
[Click to Enlarge](#)



Display Power Consumption
The display power was measured using a Linear Regression between Luminance and AC Power with a fully charged battery.

While LCDs remain more power efficient for images with mostly full screen white content (like all text screens on a white background, for example), OLEDs are more power efficient for typical mixed image content because they are emissive displays so their power varies with the Average Picture Level (average Brightness) of the image content over the entire screen. For OLEDs, Black pixels and sub-pixels don't use any power so screens with Black backgrounds are very power efficient for OLEDs. For LCDs the display power is fixed and independent of image content. **Currently, OLED displays are more power efficient than LCDs for Average Pictures Levels of 65 percent or less, and LCDs are more power efficient for Average Picture Levels above 65 percent.** Since both technologies are continuing to improve their power efficiencies, the crossover will continue to change with time.

For OLEDs the Display Power depends on the Picture Content.
An entirely Black OLED Screen uses 0 watts of Display Power.

Categories	iPhone X	Comments
Average Display Power Maximum Brightness at 50% Average Picture Level	50% Average Picture Level 1.75 watts with 700 cd/m ² 12.8 inch ² Screen Area	This measures the Average Display Power for a typical range of image content.
Maximum Display Power Full White Screen at Maximum Brightness	Maximum Power Full Screen White 3.25 watts with 634 cd/m ² 12.8 inch ² Screen Area	This measures the Maximum Display power for a screen that is entirely Peak White.

About the Author
[Dr. Raymond Soneira](#) is President of DisplayMate Technologies Corporation of Amherst, New Hampshire, which produces display calibration, evaluation, and diagnostic products for consumers, technicians, and manufacturers. See [www.displaymate.com](#). He is a research scientist with a career that spans physics, computer science, and television system design. Dr. Soneira obtained his Ph.D. in Theoretical Physics from Princeton University, spent 5 years as a Long-Term Member of the world famous Institute for Advanced Study in Princeton, another 5 years as a Principal Investigator in the Computer Systems Research Laboratory at AT&T Bell Laboratories, and has also designed, tested, and installed color television broadcast equipment for the CBS Television Network Engineering and Development Department. He has authored over 35 research articles in scientific journals in physics and computer science, including Scientific American. If you have any comments or questions about the article, you can contact him at dso.info@displaymate.com.

DisplayMate Display Optimization Technology
All Smartphone, Tablet, Monitor and TV displays can be significantly improved using DisplayMate's proprietary very advanced scientific analysis and mathematical display modeling and optimization of the display hardware, factory calibration, and driver parameters. We help manufacturers with expert display procurement, prototype development, display performance improvement and optimization, testing displays to meet contract specifications, and production quality control so that they don't make mistakes similar to those that are exposed in our public Display Technology Shoot-Out series for consumers. This article is a lite version of our advanced scientific analysis – before the benefits of our [DisplayMate Display Optimization Technology](#), which can correct or improve all of these issues. If you are a display or product manufacturer and want to significantly improve display performance for a competitive advantage then [Contact DisplayMate Technologies](#).

About DisplayMate Technologies
[DisplayMate Technologies](#) specializes in proprietary advanced scientific display calibration and mathematical display optimization to deliver unsurpassed objective performance, picture quality and accuracy for all types of displays including video and computer monitors, projectors, TVs, mobile displays such as Smartphones and Tablets, and all display technologies including LCD, OLED, 3D, LED, LCoS, Plasma, DLP and CRT. This article is a lite version of our intensive scientific analysis of Smartphone and Smartphone mobile displays – before the benefits of our advanced mathematical [DisplayMate Display Optimization Technology](#), which can correct or improve many of the display deficiencies. We offer DisplayMate display calibration software for consumers and advanced DisplayMate display diagnostic and calibration software for technicians and test labs.

For manufacturers we offer Consulting Services that include advanced Lab testing and evaluations, confidential Shoot-Outs with competing products, calibration and optimization for displays, cameras and their User Interface, plus on-site and factory visits. We help manufacturers with expert display procurement, prototype development, and production quality control so they don't make mistakes similar to those that are exposed in our Display Technology Shoot-Out series. See our world renown [Display Technology Shoot-Out](#) public article series for an introduction and preview. DisplayMate's advanced scientific optimizations can make lower cost panels look as good or better than more expensive higher performance displays. If you are a display or product manufacturer and want to turn your display into a spectacular one to surpass your competition then [Contact DisplayMate Technologies](#) to learn more.

- Article Links: [Apple iPhone 7 LCD Display Technology Shoot-Out](#)
Article Links: [Samsung Galaxy Note8 OLED Display Technology Shoot-Out](#)

Article Links: [Display Color Gamuts Shoot-Out NTSC to Rec.2020](#)
Article Links: [Absolute Color Accuracy Display Technology Shoot-Out](#)
Article Links: [Watching Displays at Night](#)

Article Links: [Mobile Display Shoot-Out Article Series Overview and Home Page](#)
Article Links: [Display Technology Shoot-Out Article Series Overview and Home Page](#)

Copyright © 1990-2017 by DisplayMate Technologies Corporation. All Rights Reserved.
This article, or any part thereof, may not be copied, reproduced, mirrored, distributed or incorporated into any other work without the prior written permission of DisplayMate Technologies Corporation

Copyright © 1990-2017 by DisplayMate® Technologies Corporation. All Rights Reserved.
[Click here for Copyright, Trademark, Warranty, Information and Legal Terms of Use](#)

Screen Resolution: This site best viewed at a resolution format of 1024x768 or 1280x1024 pixels.
Printing: If your browser is improperly printing some pages with text cutoff on the right edge then print in Landscape mode or reduce the font size (View Menu - Text Size) and margins (File Menu - Page Setup).