IEEE P1858 CPIQ Overview

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What is CPIQ?

- CPIQ = Camera Phone Image Quality
- Image quality standards organization for mobile cameras (not just phones anymore)
- Launched 2006 under International Imaging Industry Association (I3A)
- Transitioned in 2012 to IEEE standards development as Work Group P1858

Who is CPIQ?

- Participating companies:
  - Cross-industry:
    - Mobile carriers, OS vendors, handset manufactures, chipset vendors, component vendors, test labs, test software and equipment vendors, and others
  - Global representation:
    - Currently >20 member companies representing Europe, US, and Asia
- Relationship to ISO:
  - Liaison relationship with ISO
  - Maintain consistency across imaging standards from different organizations

Why CPIQ?

- Reviewers and consumers starting to understand that megapixels ≠ image quality
- Need alternative way to asses & communicate image quality
- CPIQ goals are to:
  - **Standardize** image quality test metrics and methodologies across the industry
  - **Correlate** objective results with human perception
  - **Combine** the data into a meaningful consumer rating system

What is Image Quality Testing?

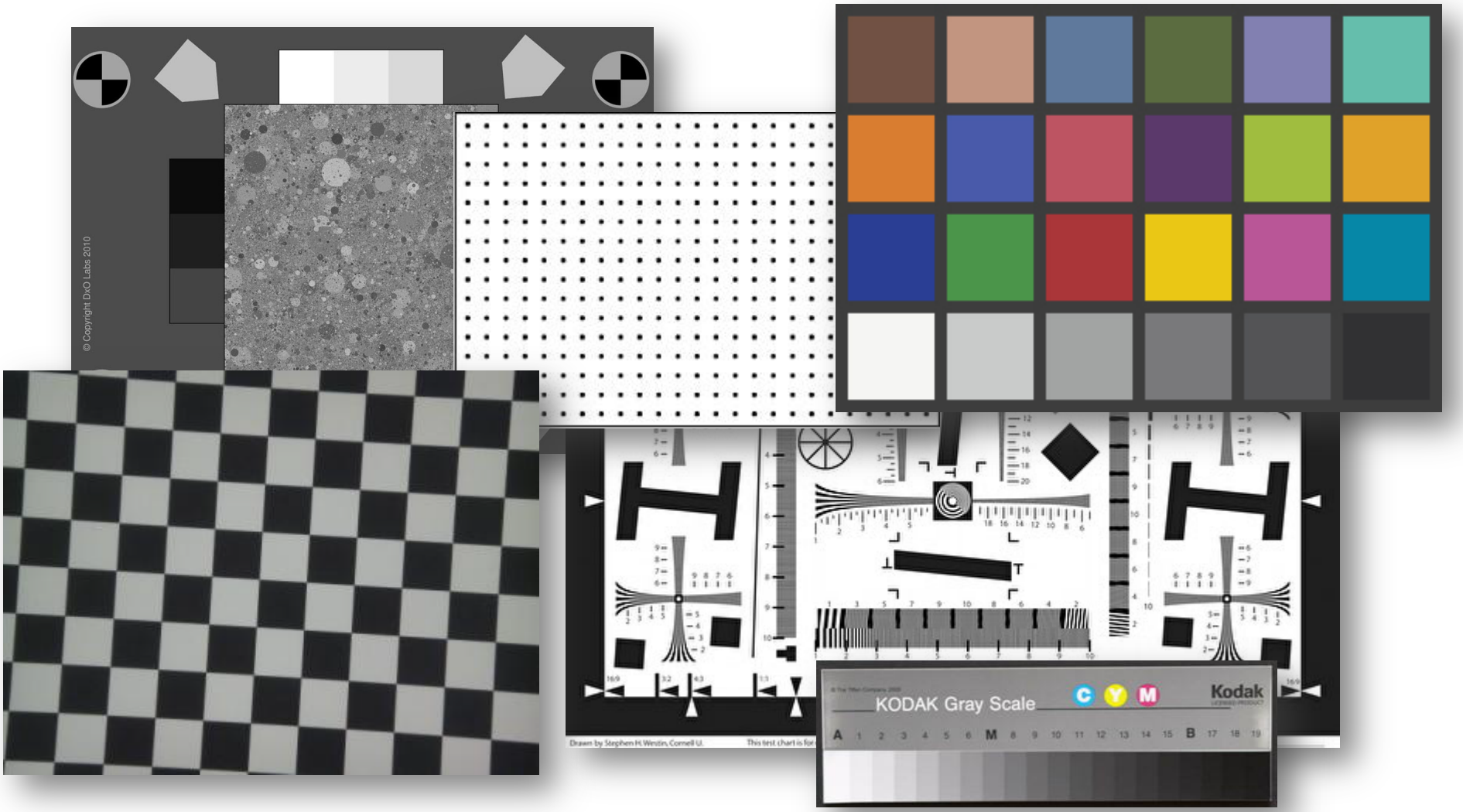
- In Academia/Research:
  - Use standard image data sets (LIVE, A57, etc.)
  - Are dealing with known distortions (white noise, Gaussian blur, JPEG, etc.)
  - Compare to reference data (full reference)
  - Collect Mean Opinion Scores (MOS)
  - Have availability of time and computation power

What is Image Quality Testing?

- In Industry:
  - No reference data
  - No access to RAW images
  - No manual control
  - No time for user study
  - Need results fast from a basic laptop

Must answer: How good is this camera?

Use Known Targets



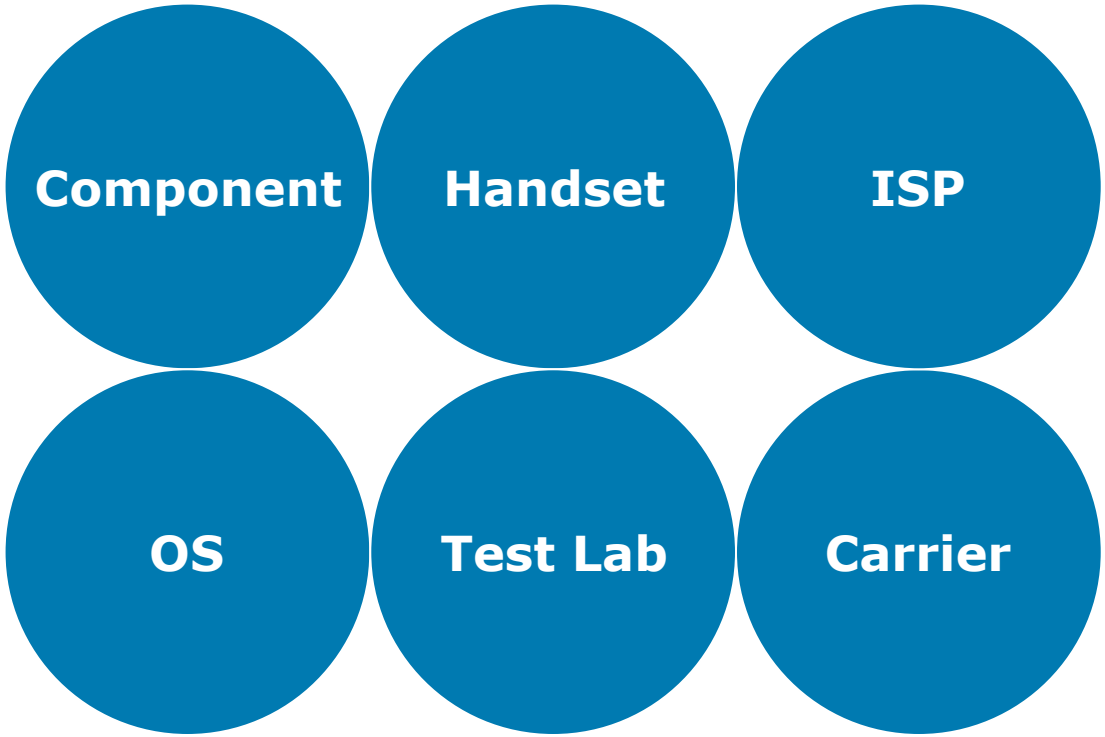
Use Many Lighting Conditions

Use Image Analysis Software

- Examples of software include, but not limited to:
  - Imatest
  - DxO Analyzer
  - Image Engineering iQ-Analyzer
  - Adobe Photoshop
  - Matlab
  - Python
  - Etc.

The Challenge: No Common Language

- Everyone measures image quality a little bit differently
- This makes working together a challenge



Many Ways to Measure IQ

- Many conditions X many metrics = endless combinations
  - The same test can be done under many different conditions
    - Test targets, light sources, light levels, color temperatures, distances, etc. all have an impact
  - There are many metrics to measure the same thing.
    - Color alone can be measured in almost twenty different ways!

$\Delta E^*_{uv} = ((L_2^*-L_1^*)^2 + (u_2^*-u_1^*)^2 + (v_2^*-v_1^*)^2)^{1/2}$

$C^*_{ab} = (a^{*2} + b^{*2})$ $\Delta L)^2 + (\Delta C)^2)^{1/2}$

$L^* = 116f(Y/Y_n) - 16$

$L^* =$

$a^* = 500[f(X/X_n) - f(Y/Y_n)]$

$b^* = 200[f(Y/Y_n) - f(Z/Z_n)]$

$Y = 0.21$

$0.0722B)^2$)

$Y' = W_R R + W_G G + W_B B = 0.299R + 0.587G + 0.114B$

$U = U_{\text{Max}} \frac{B - Y'}{1 - W_B} \approx 0.492(B - Y')$

$V = V_{\text{Max}} \frac{R - Y'}{1 - W_R} \approx 0.877(R - Y')$

$s_{ab} = \frac{C^*_{ab}}{L^*} = \frac{\sqrt{a^{*2} + b^{*2}}}{L^*}$

$s_{uv} = \frac{C^*_{uv}}{L^*} = 13\sqrt{(u' - u'_n)^2 + (v' - v'_n)^2}$

$\begin{aligned} Y' &= 16 + (65.481 \cdot R' + 128.553 \cdot G' + 24.966 \cdot B') \\ C_B &= 128 + (-37.797 \cdot R' - 74.203 \cdot G' + 112.0 \cdot B') \\ C_R &= 128 + (112.0 \cdot R' - 93.786 \cdot G' - 18.214 \cdot B') \end{aligned}$

Chroma % = 100% mean(( )

If Company A measures 10 and Company B measures 20, who's to say who's right?

IEEE P1858 CPIQ Standard

- Standardizing means everyone measures the same way
- Version 1 of *CPIQ Standard for Image Quality Testing* is planned to be published in 2016
- Will include seven metrics:
  - Spatial frequency response
  - Lateral chromatic displacement
  - Chroma level
  - Color uniformity
  - Local geometric distortion
  - Visual noise
  - Texture blur

Spatial Frequency Response (SFR)

- Measure of resolution, sharpening, acutance and image sharpness
- Derived from ISO 12233 – *Photography Electronic Still Picture Imaging – Resolution and Spatial Frequency Response Measurements*
- Adds a method for calculating a visually correlated global sharpness measure (acutance)
- Measured on a low-contrast slanted edge
- Current version only calculates SFR of image center
  - Continuing work planned to add corner/edge sharpness

Lateral Chromatic Displacement

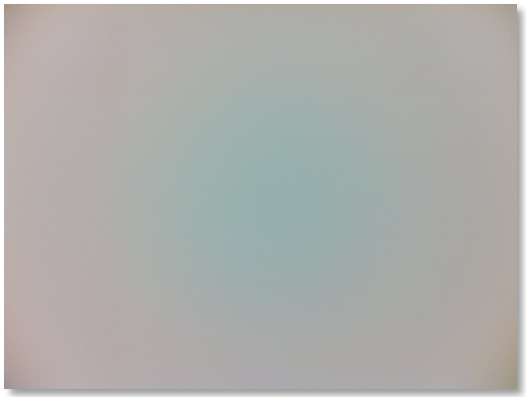
- Caused by different wavelengths of light being focused at different positions in the focal plane
- Measured on a target of black dots over a uniform white background
- Reported as the worst case shift of color planes over the whole image as a proportion of the image height.
- Adopted by ISO as International Standard 19084

Chroma Level

- Measures average scene colorfulness and links it to end users preference.
- Chroma is often used to indicate color *intensity* and is used in this standard as an approximation of saturation.
- Saturation measures deviation from accurate colorimetric reproduction, whereas Chroma Level is derived from user studies.
- Measured on a 140 patch color target
- Reported as percentage of the ratio of mean chroma between captured image and reference data

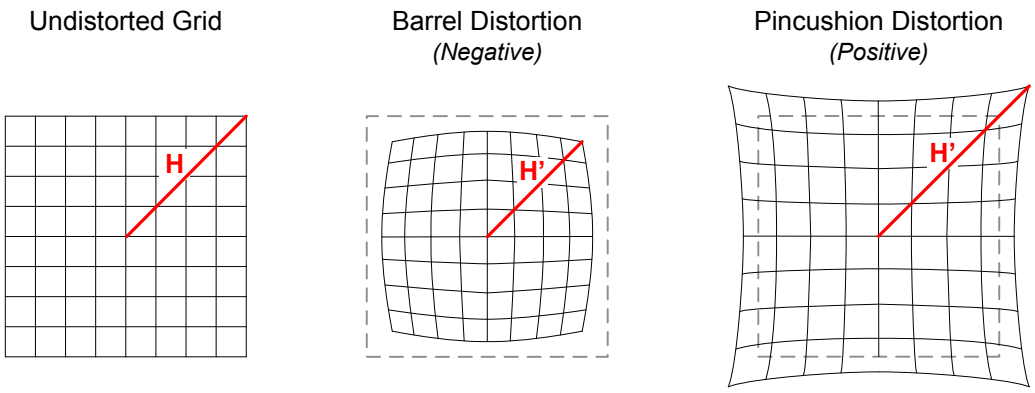
Color Uniformity

- Typically seen as radial color variation across an image
- Can be caused by
  - optical mismatch between sensor and lens
  - spatially varying spectral transmittance differences from the IR filter
  - spectral sensitivity differences across the sensor
- Measured on neutral flat-field (uniform) target
- Reported as the maximum color deviation from the scene average
- Adopted by ISO as International Standard 17957



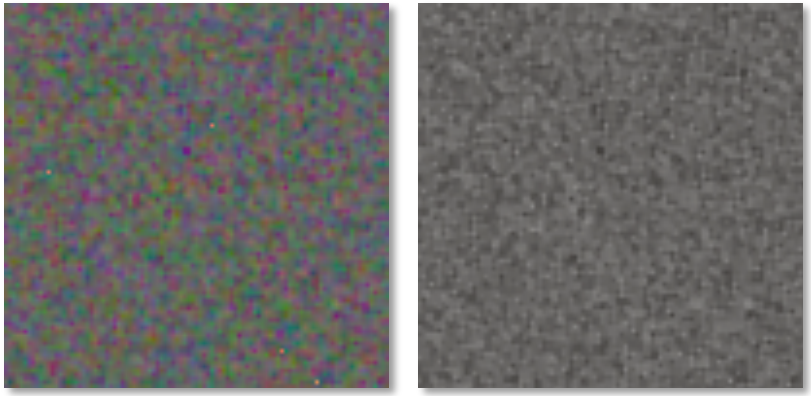
Local Geometric Distortion

- Defined as the variation of magnification in the image field. (The most well known effect of distortion is that straight lines appear warped.)
- Measured on a target of black dots over a uniform white background
- Reported as the largest absolute value of the distortion in the image field
- Adopted by ISO as International Standard 17850



Visual Noise

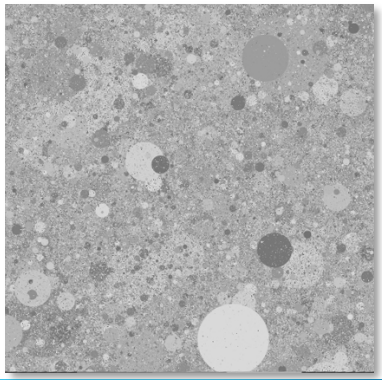
- Derived from ISO 15739:2013 – *Noise measurements*
- Shows better correlation with visual perception of noise than ISO 15739.
- Measured on a ISO 14524:2009 compliant OECF chart
- Reported as base 10 logarithm of the weighted sum of the L*, a*, b* variances and L*a* covariance
- Rewards for noise in blue-yellow axis due to –b* term
- This & other aspects of metric planned to be refined for V2



Texture Blur

- Strong noise reduction can preserve edges (and hence give good SFR results) but destroy texture
- Measured on “dead leaves” target
- Reported as a ratio between the power spectral density (PSD) of the captured dead leaves patch minus the PSD of a flat field patch (in order to compensate for the noise), and the PSD of the ideal (reference) dead leaves target.
- V1 may not provide accurate results for NR algorithms that apply localized NR strength based on image content





Subjective Correlation

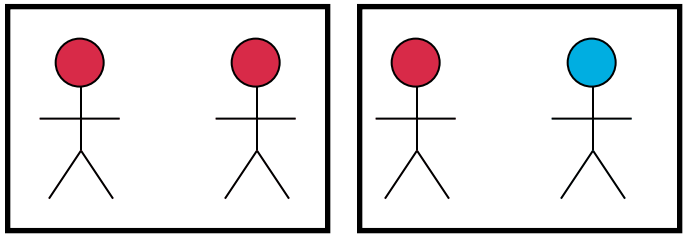
- Now we are all measuring the same thing, but what does it mean?
- Need to correlate objective results with perceived quality
- This is where CPIQ and ISO standards differ

Now Company A measures 10 and Company B measures 10, but is 10 good?

The Quality Ruler Method

- **ISO 20462 Part 3 – The Quality Ruler Method**
  - Used to correlate objective measurements with subjective perception
  - Standardization of **anchored pair comparison** method of psychophysical testing
  - Based on **Just Noticeable Difference** (JND) units
    - JND is the smallest statistically measurable difference of perception
    - Typically, defined when half of the people perceive a difference and the other half are guessing

50% perceive a change

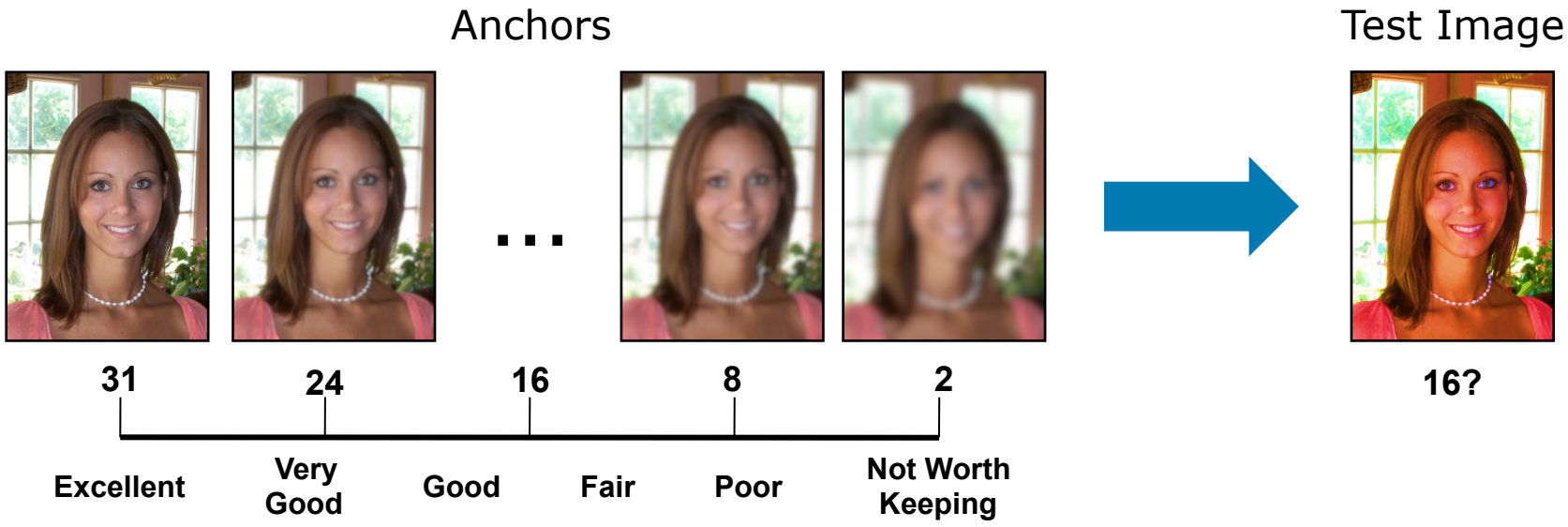


50% guessing

75% of judgments correct, 25% incorrect

Anchored Pair Comparison

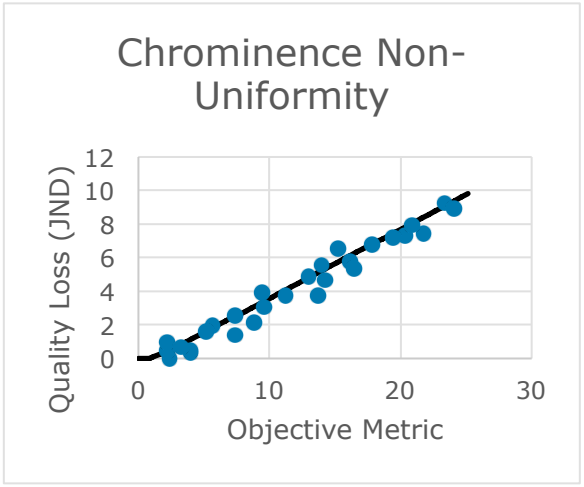
- Image references (anchors) form basis of quality scale
  - Anchors step in quality from high to low
  - Calibrated to numerical scale of 30 JND values in sharpness
- Test images are compared to anchors for position of closest match in quality

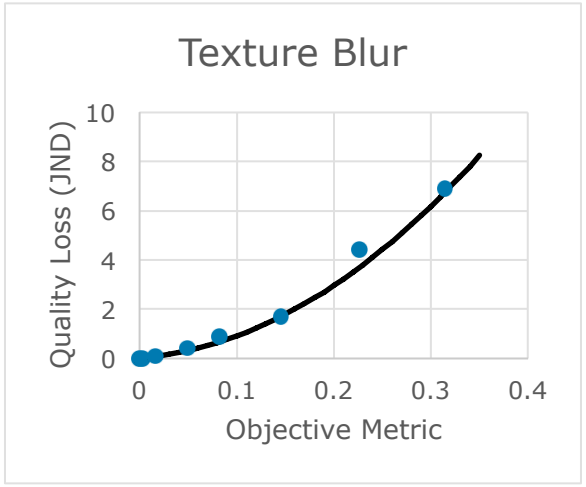


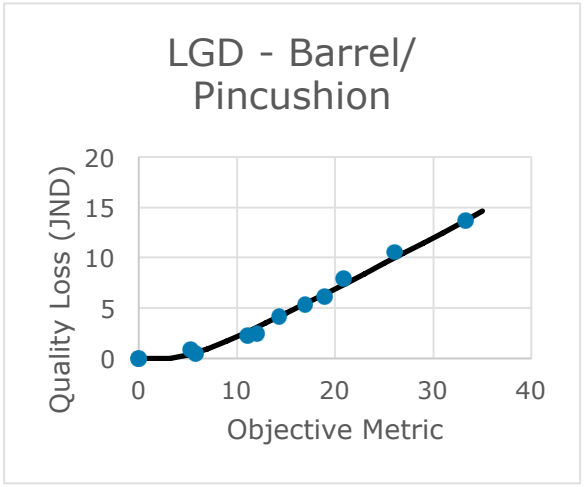
Softcopy Quality Ruler

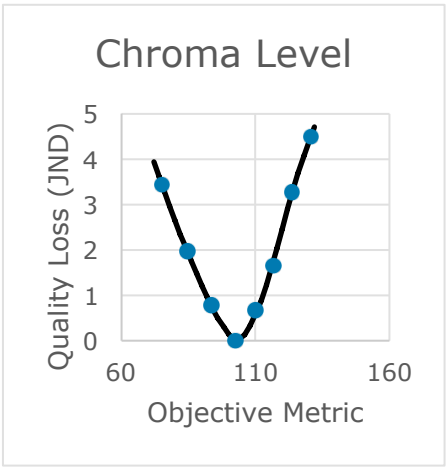
- Simultaneous viewing of ruler and test image on monitor
- Controlled environment: monitor, viewing distance (chin/ head rest), ambient lighting
- Facilities available at several participating companies.

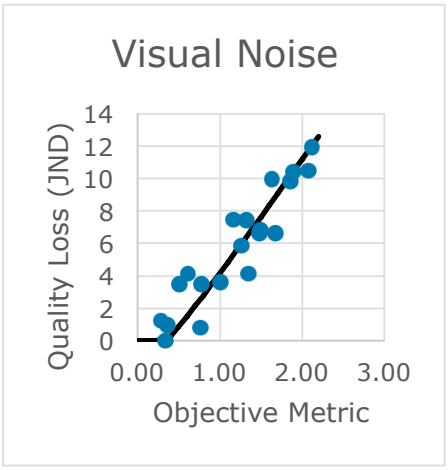
JNDs for Published Standards

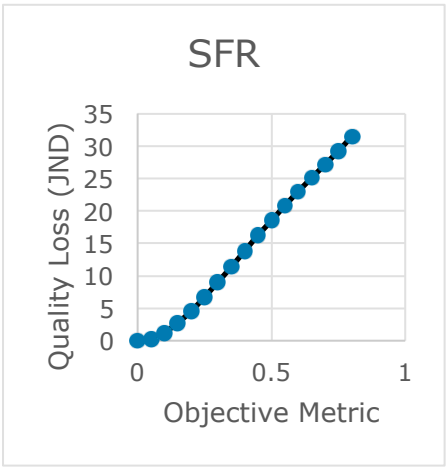


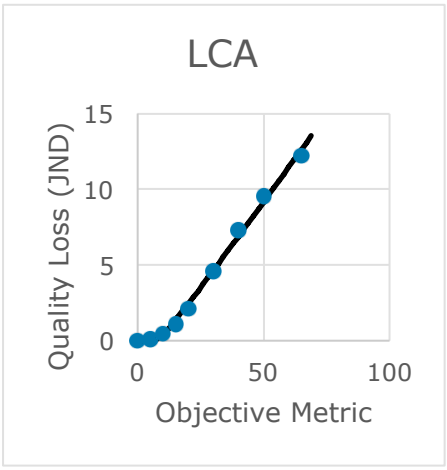












Too Much Information

- So we have all this data, now what?
- Goldmine for the image scientist and engineer
- Overwhelming and meaningless for the average consumer (and executive) who just want to know:
  - "So is this a good quality camera or isn't it?"

*Need a **concise** and **meaningful** way to answer this question.*

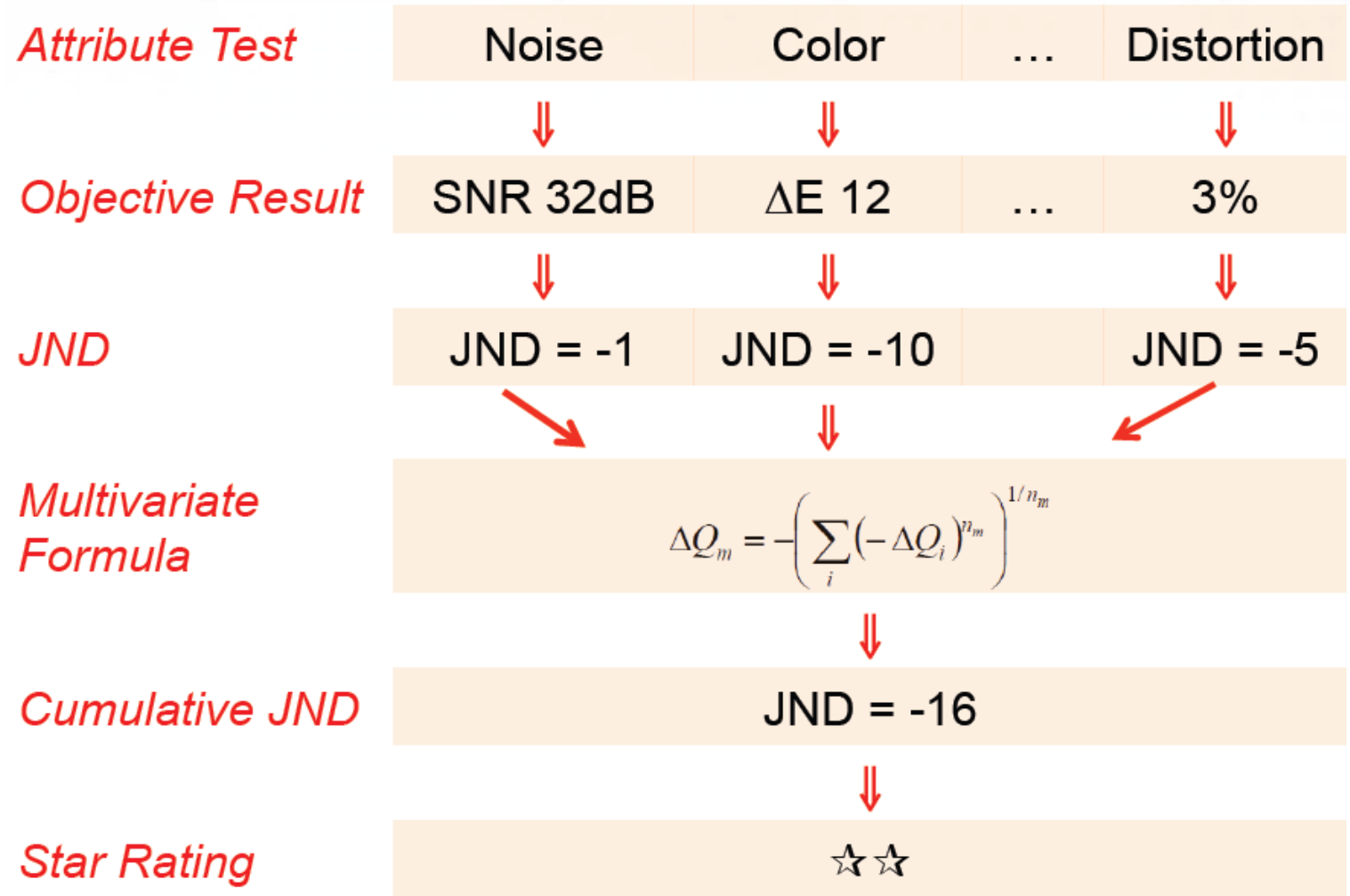
ICAP - IEEE Conformity Assessment Program

- CPIQ Conformity Assessment Steering Committee (CASC)
  - Formed 2014, 13 member companies
- CPIQ CASC Objectives:
  - Create a meaningful, easy to understand **consumer rating system** (CRS) for mobile cameras
  - Create and manage a mobile camera **certification program** to award ratings

Benefits of a CRS

- Enable **carriers**, manufacturers and reviewers to effectively convey the image quality of mobile cameras
  - Prevent negative user experience by helping to set expectations
  - Market to specific segments (e.g. Selfies, printing, HD, 4K)
- Enable **consumers** to select the right mobile camera for their needs
  - Make informed, educated decisions
  - Push the industry towards better devices
  - Have a relevant and understandable way to compare devices
- Provide consumer **protection** in the form of independent verification of results
  - CPIQ Certification Program by independent 3rd party test labs

From Specs to Stars



CPIQ Next Steps

- Version 2 of *CPIQ Standard for Image Quality Testing* targeted for 2017 publication
- Will include:
  - Auto White Balance
  - Auto Exposure
  - Video
  - AF Consistency
  - Revised Texture Metric
  - Updates to Visual Noise
  - Updates to SFR Metric

CPIQ Next Steps

- Many more metrics remain:
  - HDR
  - Local tone mapping
  - Visible Dynamic Range Capability
  - Spatial non-uniformity (vignetting)
  - Veiling Glare
  - Image Stabilization
  - Video Stabilization
  - Memory Color
  - Extended color gamut
  - Flash
  - Horizontal and vertical edge measurements
  - AF Speed
  - Latency
  - Artifacts
  - Panorama

ICAP Next Steps

- Develop the Consumer Rating System formula
- Conduct Consumer Rating System validation study
- Prepare test spec and documentation
- Develop certification program guidelines
- Administer certification programs
- Market the Consumer Rating system to build brand awareness

How to Join

- To join the IEEE P1858 Working Group and/or the CPIQ Conformity Assessment Steering Committee, contact:
  - icap-team@ieee.org