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Author(s): Paul Conway, Don Williams, 2008-2011.

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SI 675 Digitization for Preservation

Week 3 – Digitization Guidelines Today

Today's Outline

- Scanning technology
- Scanning specifications
- Federal Agencies Digitization Guidelines
- Metamorfoze benchmarks

*"**Image literacy (n):** The ability to read, interpret and use generally accepted imaging results, to handle the corresponding performance information, to express ideas and opinions, to make decisions and solve related problems."*

Williams/Burns (2009)

What is an Image... and how is it characterized ?

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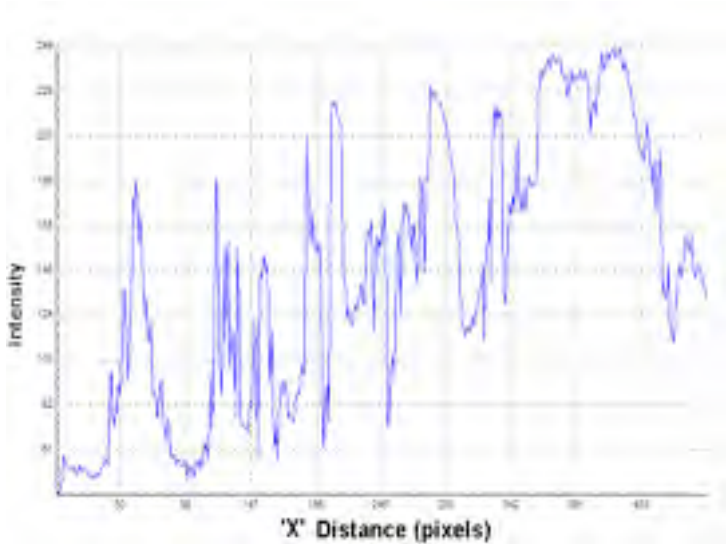
A two dimensional spatial structure of varying light levels and colors.

It is characterized by measuring physically realizable light intensities over a two dimensional space. These variations can occur over short distances, like edges, (high frequencies) or larger distances or areas, like sky or facial features (low frequencies).



'y'

'x'

The Big Picture - General Imaging Steps -

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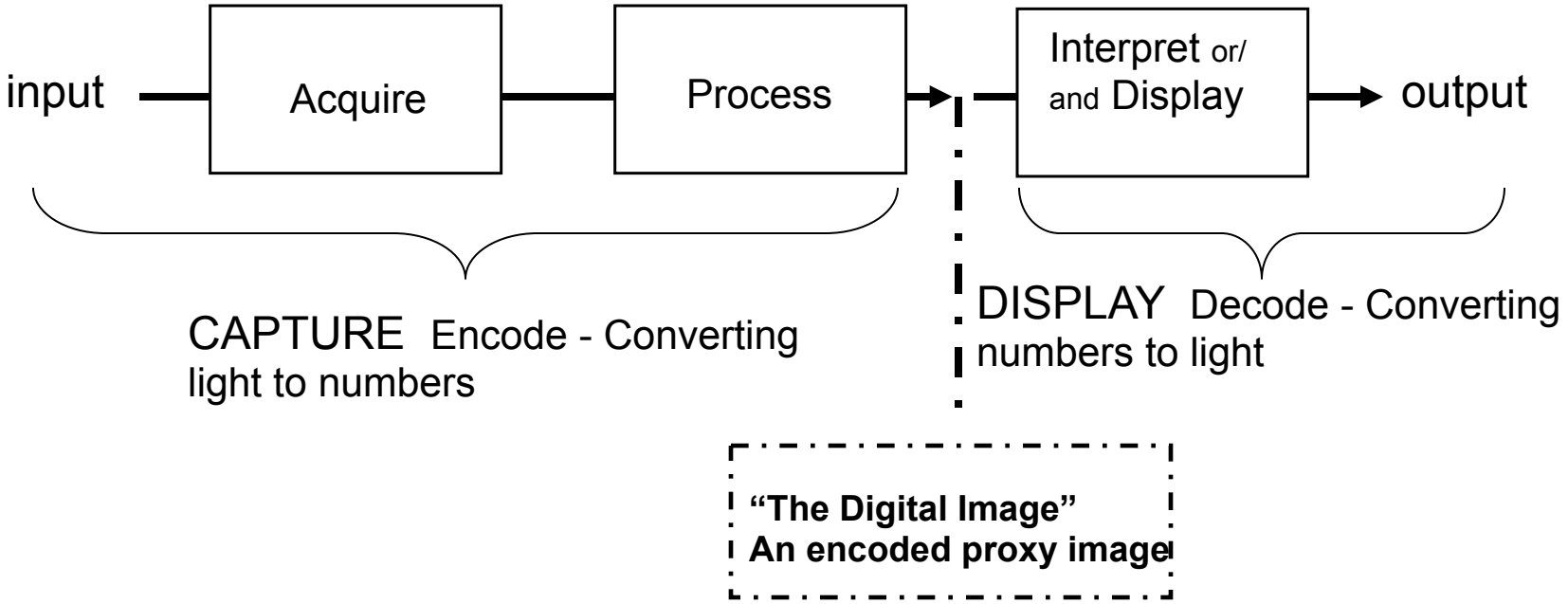

Imaging Performance Metrics indicate how an imaging system or component acts on, modifies or limits the effective optical characteristics of an input scene.

Once digitally captured, the image ceases to exist as light intensities. They are now encoded as N-bit (M channel) digital files. Because the encoding is easily manipulated, ISO imaging capture performance metrics attempt to trace the data back to the original scene input intensities (input referred) or expected output intensities (output referred)

What is a Digital Imaging System?

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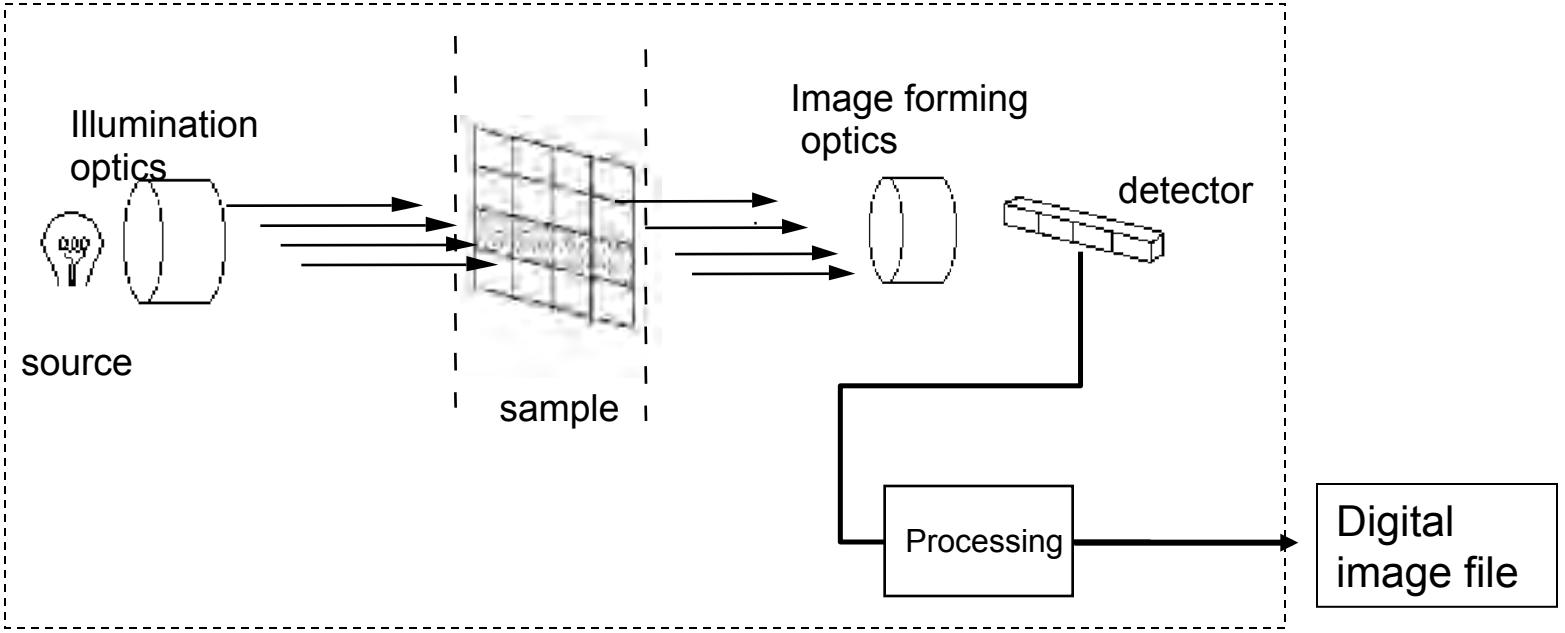
A collection of optical, software, or electronic functions that convert, encode, or otherwise act upon images or their optical or digital derivatives.



The performance of a digital capture system is influenced by all of the above in addition to operator training and environment.

Optical properties of objects

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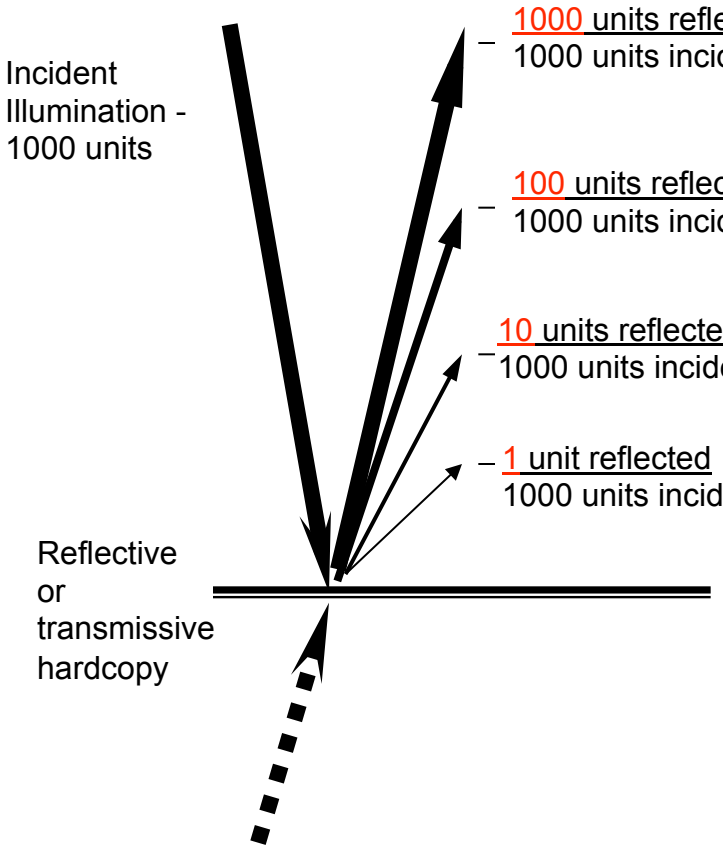

1000 units reflected / 1000 units incident = 1.000 reflectance = 0.0 density

100 units reflected / 1000 units incident = 0.1000 reflectance = 1.0 density

10 units reflected / 1000 units incident = 0.0100 reflectance = 2.0 density

1 unit reflected / 1000 units incident = 0.0010 reflectance = 3.0 density

Density= - log10 (reflectance)

* In practice, it is often more convenient to specify in terms of density, especially for densities greater than 1.0

Know your Collection

- Typical density ranges for collection content -

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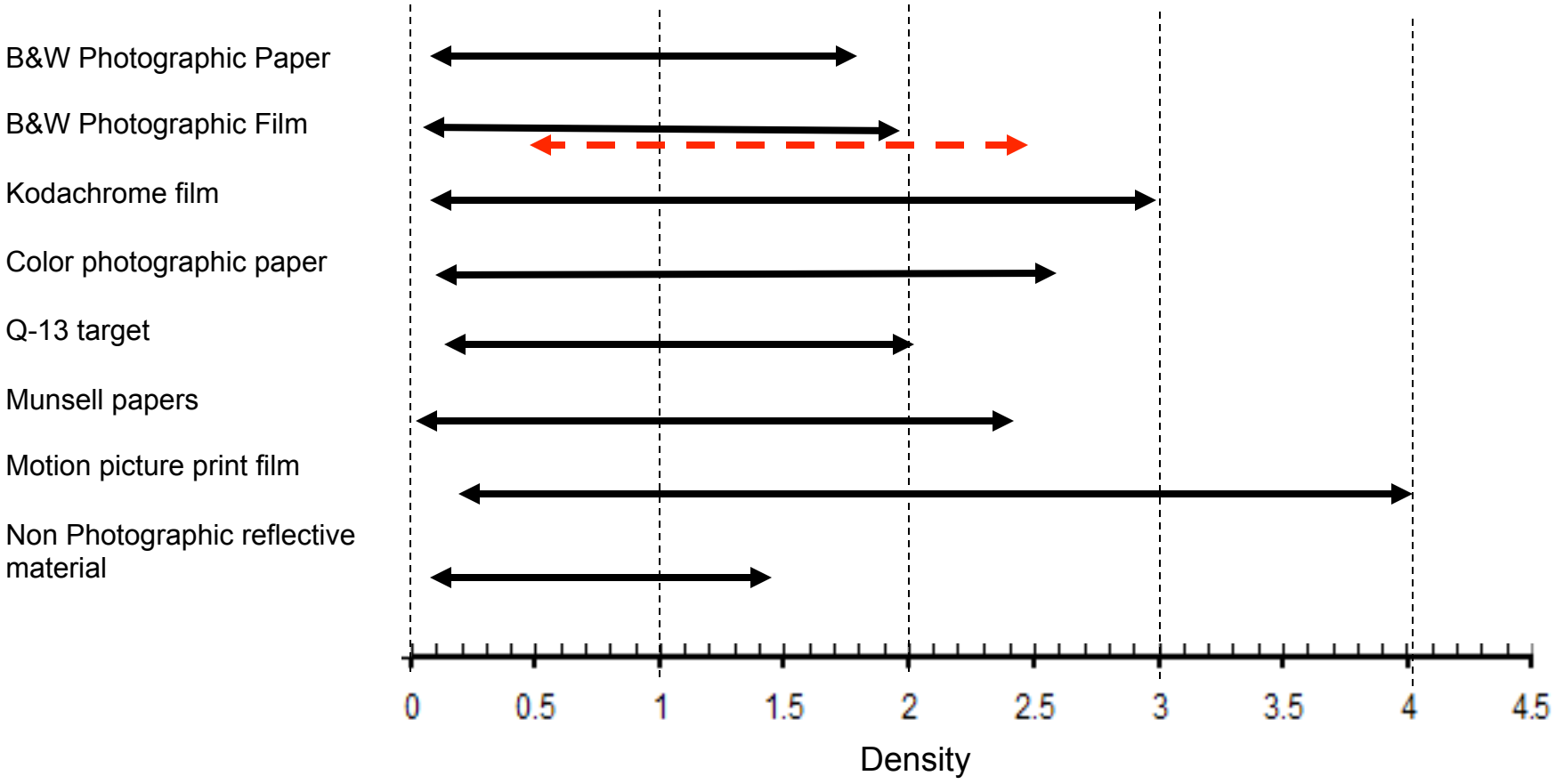

Types of Digital Capture Systems

- Scanners vs. Cameras -

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- Fully Integrated – all capture components combined into a single plug-and-play scanner unit
  - Flatbed scanners – Epson ($), Creo IQSmart3 ($$$)
  - Copy Stand – Zeutschel, I2S products, Stokes
  - Special Purpose - Kirtas, Treventus, and Qidenus

- D-I-Y Copy stands (i.e. camera-on-a-stick)
  - Camera Backs – Betterlight, Hasselblad, Sinar,
  - Digital SLRs – Canon EOS, Nikon

Popular Detector Arrangements

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Linear arrays – one dimensional ordered arrangement of single detectors

Area arrays – two dimensional ordered arrangement of single detectors.

Step and Repeat (Macro or Micro) area strategy – capture and combine several area captures into a single large image

Linear Arrays (Tri-linear)

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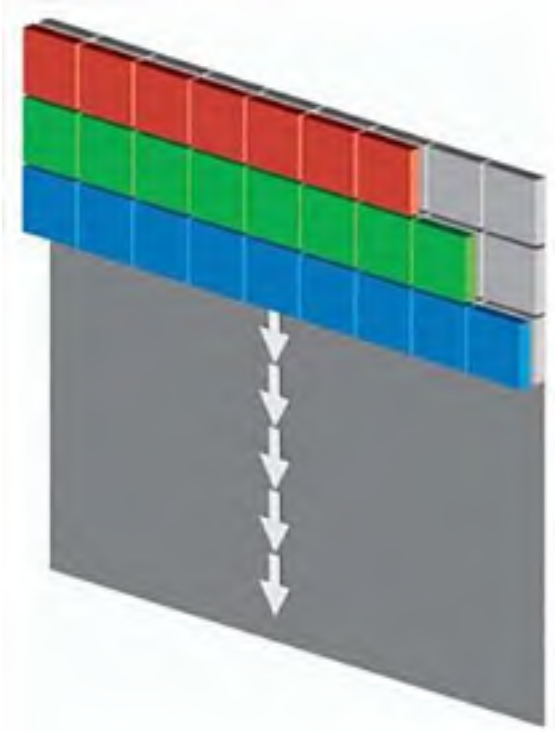
- Three filtered (Red, Green, Blue) rows of sensors
- The sensor stares at the object in the row dimension and scans by the object in other direction. Sometimes called a pushbroom.
- Used in scan back cameras (e.g. BetterLight, PhaseOne FX, Seitz), flatbed scanners and most film scanners.
- Frequently have different performance behaviors in the two directions different directions



From : The Focal encyclopedia of photography

2-D Area Arrays
- Color Filter Array (CFA) pattern -

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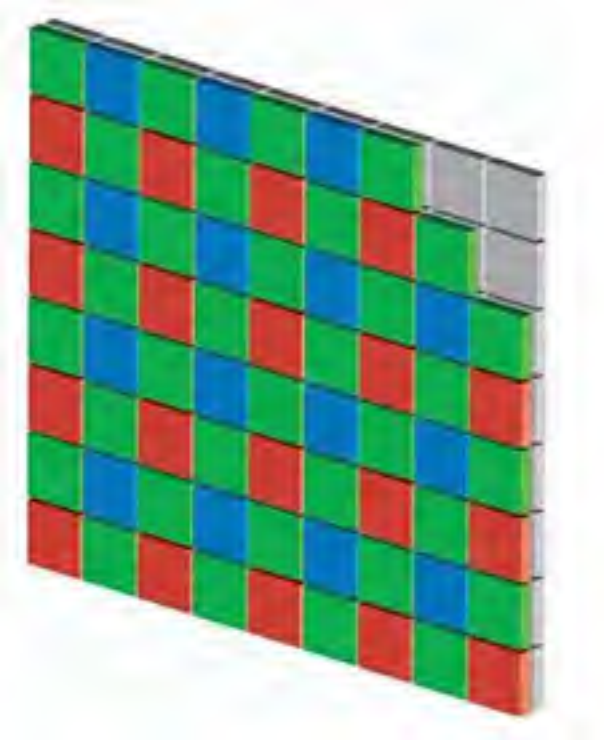
- Three filter mosaic pattern (Red, Green, Blue) of sensors. Sometimes other patterns are used but the “Bayer” pattern (shown here) is by far the most popular. Used in virtually all consumer and professional digital cameras
- One shot /one layer, sparsely populated color capture. Fully populated color achieved by interpolation algorithms (demosaicing) or micro-stepping.
- Color filters integrated onto the sensor chip at manufacturing.
- Occasionally will have subtle checkerboard artifacts or color aliasing rainbows in final delivered image.



From : The Focal encyclopedia of photography

Guidelines Specifications – Raw Data

Number	Document Name	Year	B/W DPI	B/W Bit Depth	col. Dpi	Color Bit Depth
1	RLG 95	1995	missing	8 (?)	missing	24 (?)
2	Frey/Reilly 96	1996	missing	8	missing	24
3	LoC RFP 96	1996	3000-5000 pixels	12	3000-5000 pixels	36
4	Cornell 96	1996	600 dpi	8	200-600 dpi	24
5	Columbia 97	1997	200-300	8	4096x6144	24
6	NARA 98	1998	200 to 300 (?)	missing	200 to 300 ppi (?)	missing
7	Fleischhauer 98	1998	500x400-4000x3000	8	500x400-4000x3000	24
8	Frey/Reilly 99	1999	300-?	missing	300-?	30 to 48 (?)
9	Kenney/Reiger 00	2000	300-400	8	300-800	24
10	UIUC 01	2001	600	8	600	24
11	CDL 01	2001	600 ppi	8	600 ppi	24
12	NINCH 02	2002	300-600	8	300-600	24
13	Western States 03	2003	missing	8 (?)	3000 to 5000 pixels	24 (?)
14	IFLA 03	2003	depends	8	depends	24
15	NARA 04	2004	400 to 800 ppi	8 to 16	400 to 800 dpi	24 to 48
16	CDL 05	2005	4000-8000 pixels	8	4000-8000 pixels	24
17	LoC 06	2006	300 ppi (or device maximum)	8	300 ppi (or device maximum)	24
18	NCEcho 07	2007	4000 pixels or 600 dpi	8	4000 pixels or 600 dpi	24
19	BCR 08	2008	400 to 800 ppi	16	400 to 800 dpi	48

Conway (2008). Photograph guidelines bitmap specifications.

Guidelines Specifications - Normalized

Document Name	Year	Sequence	B/W DPI	B/W Bit Depth	col. Dpi	Color Bit Depth
RLG 95	1995	1	**300**	8	**300**	24
Frey/Reilly 96	1996	2.2	**500**	8	**500**	24
LoC RFP 96	1996	2.5	500	12	500	36
Cornell 96	1996	2.8	600	8	600	24
Columbia 97	1997	3	300	8	614	24
NARA 98	1998	4.3	300	**8**	300	**24**
Fleischhauer 98	1998	4.6	500	8	500	24
Frey/Reilly 99	1999	5	300	**12**	300	48
Kenney/Reiger 00	2000	6	400	8	800	24
UIUC 01	2001	7.3	600	8	600	24
CDL 01	2001	7.6	600	8	600	24
NINCH 02	2002	8	600	8	600	24
Western States 03	2003	9.3	**500**	8	500	24
IFLA 03	2003	9.6	**600**	8	**600**	24
NARA 04	2004	10	800	16	800	48
CDL 05	2005	11	800	8	800	24
LoC 06	2006	12	300	8	300	24
NCEcho 07	2007	13	600	8	600	24
BCR 08	2008	14	800	16	800	48

Conway (2008). Photograph guidelines bitmap specifications.

Have Guidelines Changed over Time?

$$BQI\,Volume = (dpi_c^2 * depth_c) + (dpi_g^2 * depth_g) * .0001$$

Like_the_Grand_Canyon, Flickr
http://creativecommons.org/licenses/by/2.0/

H2a. Pre/Post 2000 Means Test

	Unweighted Volume pre to post 2000			
	Mann-Whitney U	Z	Asym. Sig	Exact Sig
Low Black/White	28	-1.414	0.157	0.182
Low Color	25.5	-1.617	0.106	0.113
Hi Black/White	18	-2.255	0.024	0.028
Hi Color	31	-1.160	0.243	0.278

H1. Linearity of Volume Measures

	Unweighted Volume					
	B	Beta	t	sig	R	R squared
Low Black/White	79.355	0.174	0.726	0.477	0.174	0.03
Low Color	385.433	0.301	1.304	0.21	0.301	0.091
Hi Black/White	755.745	0.547	2.694	0.015	0.547	0.299
Hi Color	1977.58	0.49	2.371	0.033	0.49	0.24

Conway (2008). Photograph guidelines bitmap specifications.

Image Performance vs. Imaging Quality

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- ***Imaging Performance***: Objectively **measured** behaviors of an imaging system in preserving information of the original object.
  - For example: Tone response, Resolution, Noise, Color error, White balance, Light falloff (uniformity)
  - Imaging Capability – Imaging Performance under optimal conditions
    - Operator
    - Environment
    - Ease of use
  - Both Accuracy and Precision are measurement requirements
- ***Image Quality:*** Task, appearance, or use case dependent measure. It is almost always some weighted **combination** of imaging performance metrics.
  - Aerial reconnaissance – high resolution and low noise
  - Health Imaging – tone control, low noise, resolution is dependent on task
  - Document Imaging – OCR accuracy
  - Consumer Imaging – Memory-color saturation, moderate resolution
    - Sharpness
    - Graininess
    - Colorfulness
    - Naturalness

Measurement Requirements

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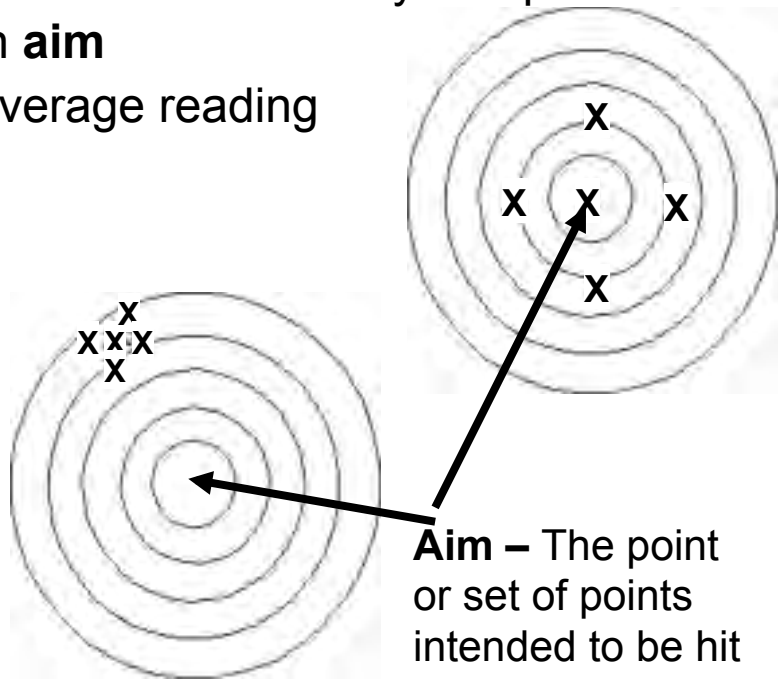
Measurements usually require some level of both accuracy and precision.

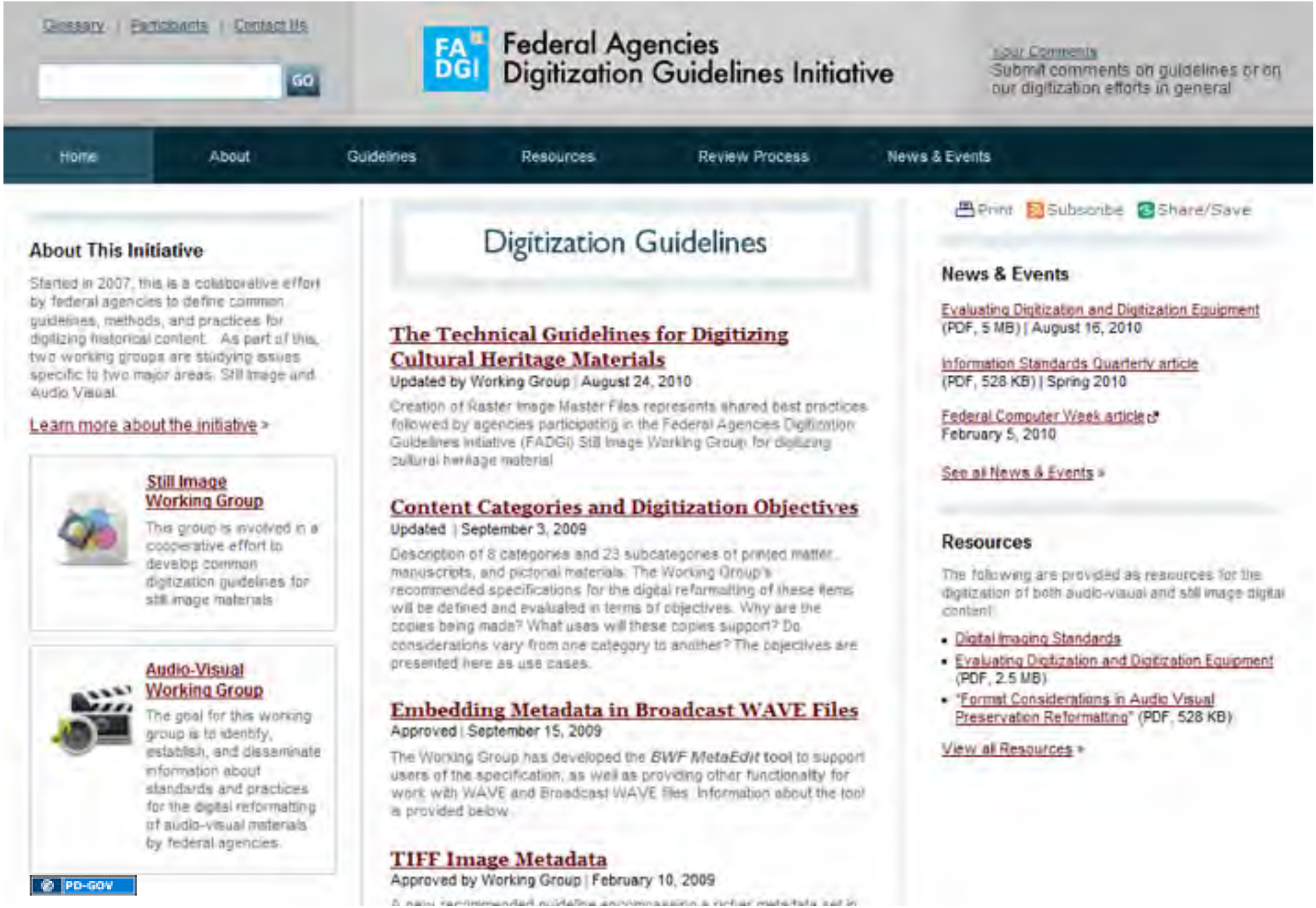
- Accuracy: average error from an **aim**
- Precision: variability about the average reading

Factors that influence measurements

- Location on platen
- Image processing
- spatial sampling
- image noise
- environment
- operator skill



Performance is more about consistency (precision) than accuracy.
In imaging, accuracy is often not absolute but rather a preference.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GO
FA DGI
Federal Agencies Digitization Guidelines Initiative
Your Comments
Submit comments on guidelines or on our digitization efforts in general
Home
About
Guidelines
Resources
Review Process
News & Events
About This Initiative
Started in 2007, this is a collaborative effort by federal agencies to define common guidelines, methods, and practices for digitizing historical content. As part of this, two working groups are studying issues specific to two major areas: Still Image and Audio Visual.
Learn more about the initiative »
Still Image Working Group
The group is involved in a cooperative effort to develop common digitization guidelines for still image materials
Audio-Visual Working Group
The goal for this working group is to identify, establish, and disseminate information about standards and practices for the digital reformatting of audio-visual materials by federal agencies.
PD-GOV
Digitization Guidelines
The Technical Guidelines for Digitizing Cultural Heritage Materials
Updated by Working Group | August 24, 2010
Creation of Raster Image Master Files represents shared best practices followed by agencies participating in the Federal Agencies Digitization Guidelines Initiative (FADGI) Still Image Working Group for digitizing cultural heritage material
Content Categories and Digitization Objectives
Updated | September 3, 2009
Description of 8 categories and 23 subcategories of printed matter, manuscripts, and pictorial materials. The Working Group's recommended specifications for the digital reformatting of these items will be defined and evaluated in terms of objectives. Why are the copies being made? What uses will these copies support? Do considerations vary from one category to another? The objectives are presented here as use cases.
Embedding Metadata in Broadcast WAVE Files
Approved | September 15, 2009
The Working Group has developed the BWF MetaEdit tool to support users of the specification, as well as providing other functionality for work with WAVE and Broadcast WAVE files. Information about the tool is provided below.
TIFF Image Metadata
Approved by Working Group | February 10, 2009
Print
Subscribe
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News & Events
Evaluating Digitization and Digitization Equipment (PDF, 5 MB) | August 16, 2010
Information Standards Quarterly article (PDF, 528 KB) | Spring 2010
Federal Computer Week article
February 5, 2010
See all News & Events »
Resources
The following are provided as resources for the digitization of both audio-visual and still image digital content:
Digital Imaging Standards
Evaluating Digitization and Digitization Equipment (PDF, 2.5 MB)
"Format Considerations in Audio Visual Preservation Reformatting" (PDF, 528 KB)
View all Resources »

Federal Agencies Digitization Guidelines

- Technical foundation in image science
- Workflow for purposes of accomplishing imaging aims.
  - Aim points
  - Color management
- Aims as specifications by record types
- Other elements of the document that make it comprehensive
  - Metadata (METS)
  - Quality management
  - Photograph digitization for preservation

http://www.digitizationguidelines.gov/

Vocabulary

- staying dry in a storm of vernacular idioms -

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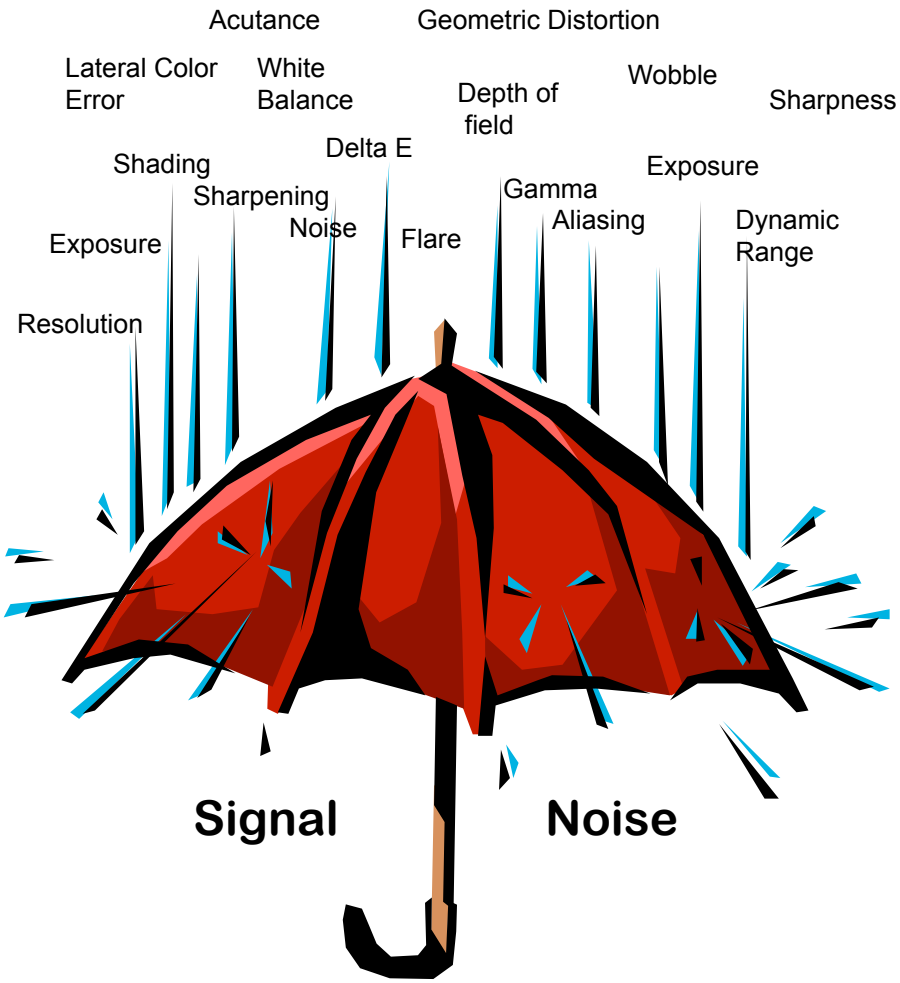

Important Imaging Characteristics

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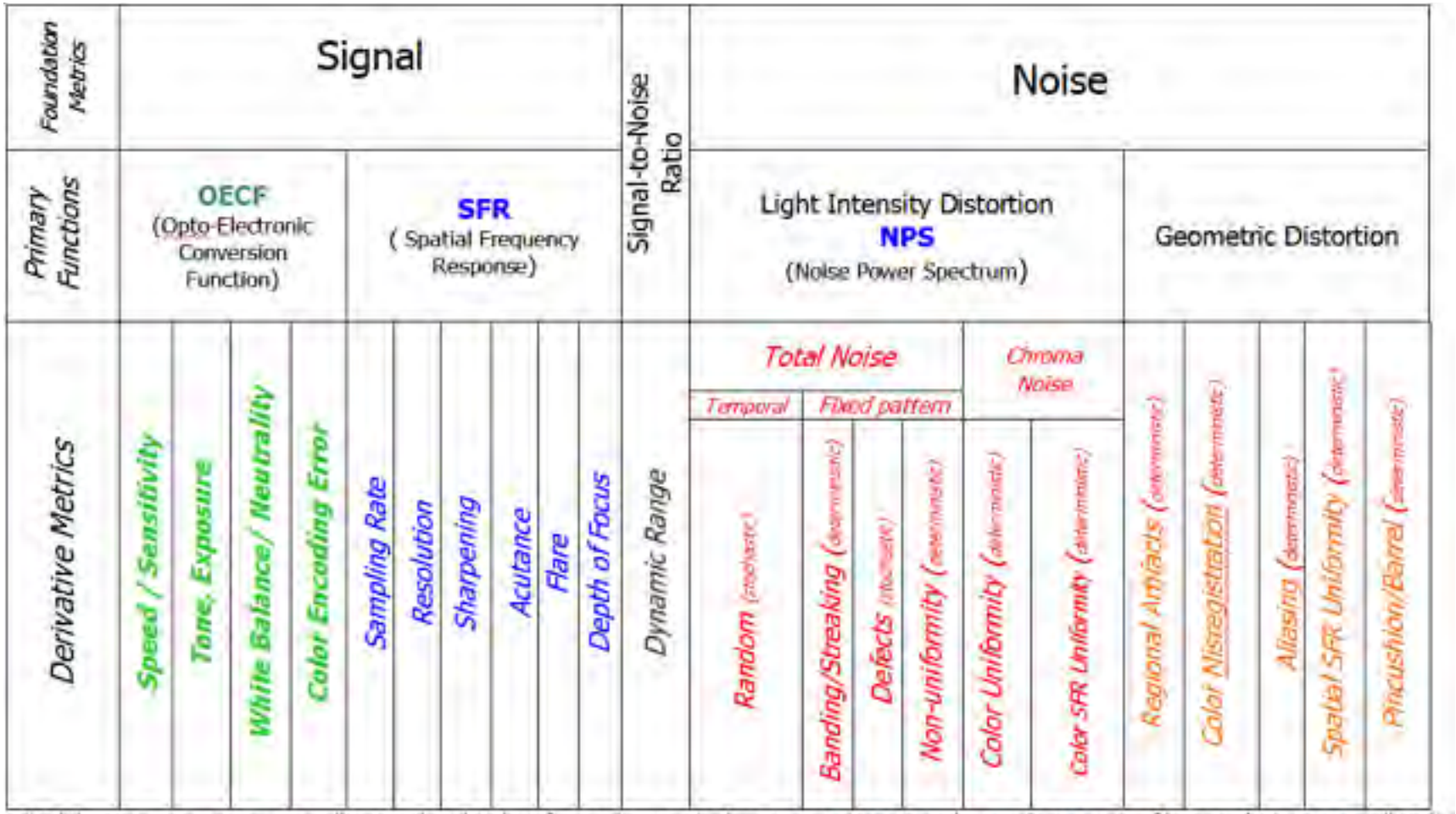
A number of these categories have ISO standards that define the metrology practice. Though intended for digital imaging devices their basis was derived from decades of analog (e.g., film) imaging experience.

Primary Imaging Performance Functions

- **Signal – Any response that provides valued information**
  - Large area response to light
    OECF -Opto-Electronic Conversion Function
  - Spatial proximity behavior
    Spatial Frequency Response – SFR (or MTF)
- **Noise – Any response that detracts from a desired signal**
  - Light intensity distortions – Total noise
  - Geometric/Spatial distortions

Imaging Performance Framework

http://www.digitizationguidelines.gov/stillimages/documents/imaging.html



* While imaging noise is generally considered to be of a random or stochastic granular nature (e.g., photographic film grain), it can actually take many forms. We have chosen to categorize it in both by its deterministic and stochastic behaviors.

PD-GOV

SIGNAL

Any response that provides valued information

Primary Functions	OECF – Opto-Electronic Conversion Function (ISO 14545) TTF – Tone Transfer Function TRC – Tone Reproduction Curve *definition* : Average large area digital response of an electronic imaging device to light stimuli			
Derivative Metrics	Sensitivity (ISO 12232) *definition:* The reciprocal of the amount of light necessary to achieve a desired output response	Tone and Exposure *definition* : characteristic behavior of large area digital output response (count value) to spectrally neutral input stimuli (gray patch)	White Balance/Neutrality *definition* : equivalence of large area color channel output responses to a range of spectrally neutral input stimuli	Color Encoding Error ISO 22028-1 *definition:* The difference between selected physically measured input colors and their intended rendering from a given color space.
Related descriptive term	- Responsivity - Speed - Exposure Index (EI)	- Too dark/light - Under/over exposed - No shadow/highlight detail - Clipping - Contrast - Exposure Accuracy - Gamma	- Color cast - Gray balance	- Over/under saturated colors - Color balance is wrong - Memory colors are not correct - Color Accuracy - Color Saturation

SIGNAL

Any response that provides valued information

Primary Functions	SFR - Spatial Frequency Response – (ISO 12233, ISO 16067-1, ISO 16067-2, ISO 15524) MTF – Modulation Transfer Function *definitions* : 1) A descriptor of an imaging system's ability to maintain the relative contrast of input stimuli of a given spatial frequency. 2) A spatial frequency descriptor of an imaging system's ability to maintain the relative contrast of features within a given spatial proximity.					
Derivative Metrics	**Sampling Rate** *Definition* : The reciprocal of the center-to-center distance between closest adjacent pixels. The number of samples per unit distance	**Resolution** *Definition* : An imaging system's ability to resolve finely spaced detail. The level of spatial detail that can resolved in an image	**Sharpening** *Definition* :Amplification of the SFR by means of image processing to achieve sharper appearing images	**Acutance** *Definition* : An objective SFR based metric that is used as a correlate to perceived image sharpness.	**Flare** *Definition:* a skirty or wide spreading of light.	**Depth of Focus** *Definition:* The distance along the optical axis that remains within acceptable focus.
Related descriptive term	- Megapixels - Dots per inch (dpi) - Pixels per inch (ppi) - Sampling frequency	- Blurred - Soft - Sharp - In/Out of focus - Spherical aberration - Spatial detail	- Oversharpening (halomy, garish edges) - Snap - Edgy, Sharp, Crisp - Edge enhancement - Unsharp masking	- Sharp	- Low contrast - Hazy - Ghosting Veiling flare - Glare - Integrating cavity effect (ICE)	- Depth of field - Circle of confusion - Focus tolerance - Hyperfocal distance

NOISE

Any response that detracts from a desired signal

Primary Function	Light Intensity Distortion – *definition:* The deviation of any given spatially imaged point from an aim energy value relative to the input object.					
Primary Functions	Noise Power Spectrum (NPS) *Total Noise* *Definition* : A spatial frequency descriptor of the sources of radiometric noise of an imaging component or system				Chromatic Noise *Definition* : The inter-color channel radiometric deviations relative to an identified aim	
Derivative Metrics	Temporal Noise	Fixed Pattern Noise			Color Uniformity (deterministic)	Color SFR uniformity (deterministic)
	Random (stochastic) *Definition* : The root mean square deviation (std. deviation) of both temporal and fixed pattern noise for a single color channel	Banding/ Streaking (deterministic) *Definition* : One dimensional patterns	Defects (stochastic) *Definition* : point or clusters of defective or poorly corrected pixels	Light Falloff (deterministic) *Definition:* A deviation in the effective illumination over a capture device's field of view; usually with lower illumination near the field's outer extent.	*Definition* : A difference in light falloff between color channels	*Definition:* The differential spread of light between color channels.
Related descriptive term	- Temporal noise - Grain - Shot noise - Read noise - White noise	- Stripes - Banding - Streaking	- Hot, Cold, or Dead Pixels - Wounded Pixels - Blinkers	- Vignetting - Relative Illumination	- Rainbows	- Colored edges - Color Bleed - Fringing

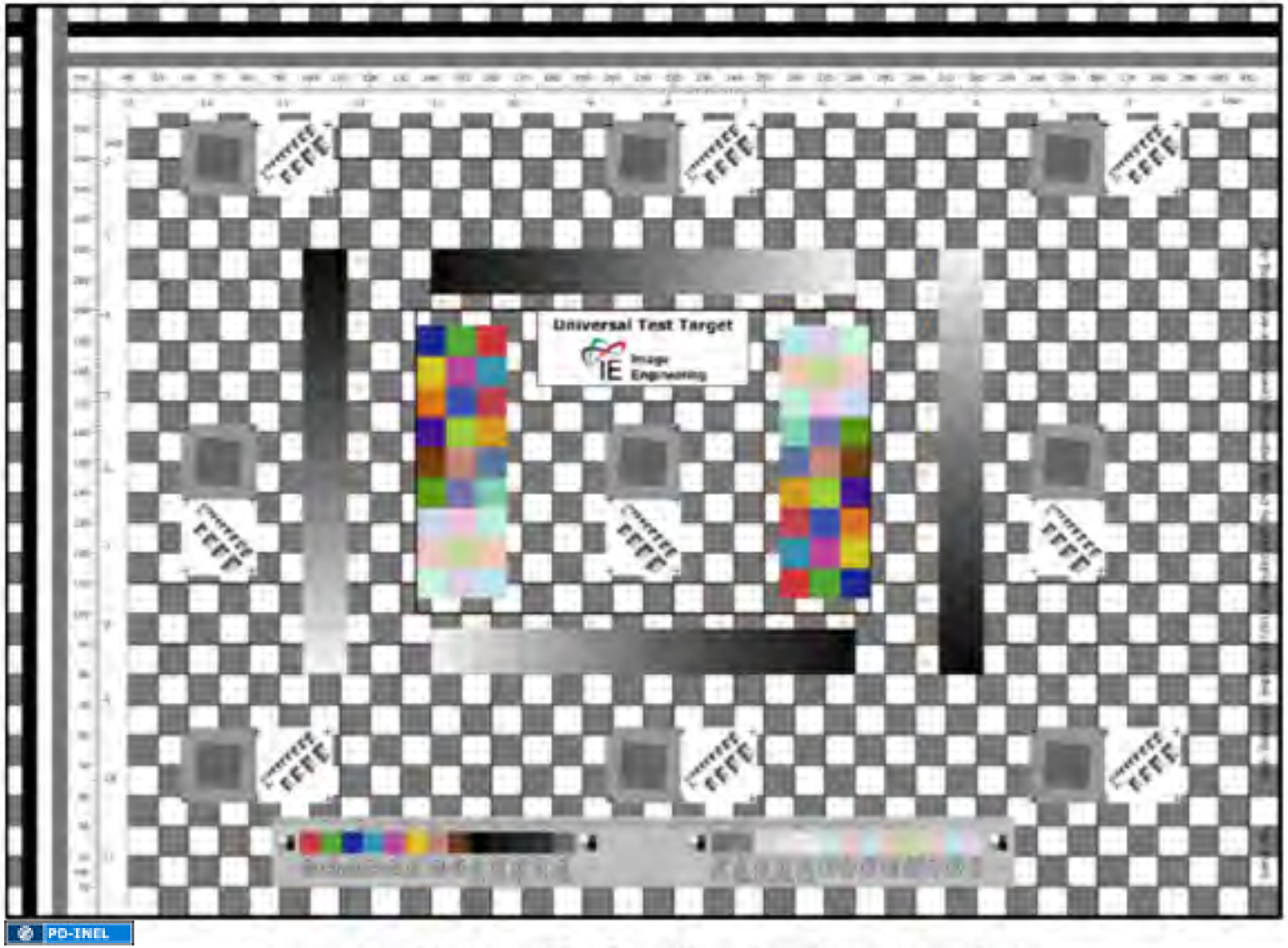
NOISE

Any response that detracts from a desired signal

Engineering Metric	– Geometric/Spatial Distortion – *definition:* The deviation of any imaged point from its intended or aim spatial position relative to the input object.				
Derivative Metrics	Field height diagram (deterministic) *Definition* : A change in magnification of an imaged object as a function of field position.	Regional (deterministic) *Definition* :A locally varying deviation in intended spatial position of an imaged object	Color Misregistration (deterministic) *Definition* : color-to-color spatial dislocation of otherwise spatially coincident color features of an imaged object.	Aliasing (deterministic) *Definition* : A sampling effect that leads to spatial frequencies being falsely interpreted as other spatial frequencies	Spatial SFR uniformity (luminance) (deterministic) *Definition:* A difference in luminance SFR as a function of optical field position
Related descriptive term	- Pincushion - Barrel - TV distortion - Field Curvature - Skew - Keystoning	- Wobble - Jitter	- Colored edges - Chromatic aberration - Lateral chromatic error(LCE)	- Jaggies - Moiré - Pixelization - Potential for aliasing	- Blurred or soft look near corners of image - Spherical Aberration - Coma

Metamorfoze

- A major project of the Koninklijke Bibliotheek,
  - National Library of the Netherlands
- Specifies “technical criteria and tolerances for preservation imaging”
- Input oriented and relate to the image quality of the “first image” only: preservation master
- Designed for Universal Test Target (UTT)
  - http://www.universaltesttarget.com/



A representation of the Universal Test Target designed according to this specification.

Image Engineering Dietmar: http://www.universaltesttarget.com/

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Thank you!

Paul Conway
Associate Professor
School of Information
University of Michigan
www.si.umich.edu