





Outline	;
What is an imaging capture sys	tem ?
 Light, Object 	
 Lens and Sensor 	
– Process	
 What is a digital image ? 	
 Methods and tools for measuring 	ig imaging performance
 Image speak : Vocabulary : Tax 	onomy
Performance metrics	
– Signal	
Resolution	
• Tone / Color	
- Noise / Artifacts	
• Light	
• Space	
- wortiow Monitoring	AIC;xx
 Test plan suggestion 	
	Reference to AIC Guide page #
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<u>Image Processing</u> - the brains -	
 Image processing functions will affect imaging performance measurements. These include, Image resizing, rotation Sharpening Tone/Color adjustments Color profile changes Noise reduction 	Test Verse Verse Verse SPREdge C014F Image: Control of the control of th
 Two approaches for performance measurement <u>Practice</u> - measure the "<i>as delivered</i>" image ficonsistent with workflow practices. <u>Benchmarking</u> – measure the raw image file we many functions as possible set to "null". 	ile /ith as
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* While in many form	Derivative Metrics	Primary Functions	Foundation Metrics	
ns. W	Speed / Sensitivity	6		
e hav	Tone, Exposure	Fun Conv		
e chos	White Balance/ Neutrality	Electro Electro ction)		
ien to	Color Encoding Error	nic	S	
categ	Sampling Rate		ign	
orize	Resolution	F Spa	<u>n</u>	
ed tr	Sharpening	tial F		
bott	Acutance	inse)		
n by	Flare	ency		
its d	Depth of Focus			
etermi	Dynamic Range	Signal-t Rat	o-Noise tio	
nistic and si	Random (stochastic)			
tocha	Banding/Streaking (deterministic)	ht In		
stic b	Defects (stochastic)	Pow N		
ehavic ehavic	Non-uniformity (deterministic)	er Spe		
e.g., p ors.	Color Uniformity (deterministic)	ctrum)	2	
notograp	Color SFR Uniformity (deterministic)	Ĕ	loise	
	Regional Artifacts (deterministic)	Ģ		
n grain),	Color Misregistration (deterministic)	sometri		
	Aliasing (deterministic)	C D		
	Spatial SFR Uniformity (deterministic)	istor	·	
tual in a la l	Pincushion/Barrel (deterministic)	- tion		32





S	oatial Frequency Response (SF	R)
	ISO 16067-1, 16067-2, 12233, 15529	
	FUNCTION CONDENSION INTERTION Home • Home • Home • NEWS & EVENTS • AUDIO-VISUAL WORKING GROUP • AUDIO-VISUAL WORKING GROUP • AUDIO-VISUAL WORKING GROUP • Bustainable Formats • Statianable Formats • RSS • E-Meil	
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		Fra	amework	Contex	t	
Primary Functions	SFR -	- Spatial Frequency Re definitions : 1) A desc 2) A spatia rel	sponse (ISO 12233, IS HTT – Modulation Transf riptor of an imaging system's a of input stimuli of a given spa al frequency descriptor of an ir lative contrast of features with	O 16067-1, ISO 16 er Function ability to maintain the r atial frequency. maging system's ability in a given spatial proxi	067-2, ISO 155 elative contrast to maintain the mity.	24)
Det native rect cert cert cert cert cert cert cer	ampling Rate efinition : The ciprocal of the nter-to-center stance between besest adjacent rels. The mber of mples per unit stance.	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 8 br term W -	legapixels ots per inch (dpi) xels per inch (ppi) ampling frequency	- Blurred - Soft - Sharp - In/Out of focus - Spherical aberration - Spatial detail	 Oversharpening (haloing, 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



	Space and Frequency	
•	Two ways to look at image details	
	 Space: size of the smallest important (signal) feature (<i>mm</i>) 	
	 Frequency: How many small important features/area will my image store (<i>number/mm, cycles/mm,</i> <i>dots/inch, pixels/inch</i>) 	
•	There is an inverse relation between size and frequency. Small size implies high frequency.	
•	Why use <i>space vs. frequency</i> descriptions?	
	 Compatible with engineering descriptions of information, bandwidth 	
	 Simplifies some forms of system analysis 	
	 Compatible with several visual image quality descriptions 	
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 In Review - The sampling frequency dictates the highest <i>potential</i> resolution, but it is the spot size and shape that regulate the actual resolution. This <i>spot</i> is known as the Point Spread Function (PSF) because it describes how light spreads spatially in an imaging system. Spot sizes much <i>larger</i> than the pixel pitch do not take full advantage of the sampling frequency. Poor optics, mis-focus, vibration and motion effects contribute to larger spot sizes and are associated with blurred images. Sampling efficiency is one way to measure this with a single number. The Spatial Frequency Response is a mathematical transformation of the PSF that can be useful for corrective action, diagnostics, and image quality prediction. 		Resolution, Spot Size, and SFR
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	•	The Spatial Frequency Response is a mathematical transformation of the PSF that can be useful for corrective action, diagnostics, and image quality prediction.
 SFRs can vary significantly in an image based on optical, mechanical and environmental factors. 	•	SFRs can vary significantly in an image based on optical, mechanical and environmental factors.
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Primary Functions	definitio	OECF – Opto-Electronic Co TTF – Tone <u>TRC</u> – Tone F m : Average large area digital resp	nversion Function (ISO 145 Transfer Function Reproduction Curve onse of an electronic imaging devi	45) ce 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	<u>Color Encoding Error</u> 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



























• Color accuracy implies that two physically realizable colors are at hand to compare. Delta E is a measure of the extent to which they are different (i.e. color error)

• Color spaces are nothing more than standardized code books of how RGB color triads should be interpreted as real colors.

• Assumptions on how RGB code values will ultimately be interpreted (i.e. rendered or decoded) as physically reproduced color are often very wrong. Include documented targets as insurance.

• Delta E metrics for digital capture devices are suitable for performance consistency monitoring but not as absolute measures of color accuracy.

• Delta E metrics are also suitable for verifying compliance of Safety Master files that are likely to be used for creating derivatives to other color spaces.

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neering Aetric	definition: The	e deviation of any image	- Geometric/Spatial Di	stortion – or aim spatial position relative	to the input object.
·편 도 민					
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 o optical field position
Related descriptive term	 Pincushion Barrel TV distortion Field Curvature Skew Kevstoning 	- 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



















Test plans	
 Design plans based on the scanning technology and features Linear arrays have streaking artifacts and bi-directional SFR behaviors. A3 and larger – lighting non-uniformity, corner SFR performance. Inspect for stitching errors on macro step and repeat devices. Inspect for 2x2, or 4x4 blocking artifacts on 4-shot and 16-shot micro-step devices Inspect for objectionable CFA reconstruction errors. Lenses and software tend to introduce the greatest variability. Forward and backward scan modes 	
 Test over reasonable and expected resolutions Most flatbed scanners will not achieve > 1200 dpi true resolution Capture replicate images at different times. 	
 Consider performance differences due to capture speed, lens F-number, and different zoom lens positions. 	
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