Whitepaper / Concept Note/Draft Standards

"Quality Aspects of Drone based EO Imaging for Land Survey Purpose"

Version - 1.0

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Coordinating Body – Centre of Excellence, DGDE, Ministry of Defence, Government of India

Centre of Excellence was established under the aegis of Director General Defence Estates, Ministry of Defence. CoE aims to leverage latest technologies like Satellite imagery, Drone imagery, geo-spatial techniques, Artificial Intelligence, Machine Learning tools in the fields of Survey of Defence Land for effective land management and urban planning for Cantonment areas. Since its inception on 16.12.2021, CoE has undertaken numerous initiatives and development of tools such as Land Use Analysis, Change Detection, etc.

CoE is also undertaking a project to conduct the Drone Survey of all Cantonments across the country. During this exercise, it was observed that there are no uniform standards of Drone imagery for Land Survey Purpose. This lack of uniformity presented a challenge in carrying out post processing analysis on the drone imagery output. The same was brought to notice during the meetings chaired by Defence Secretary, Government of India, wherein it was decided to conduct literature review and prepare draft standards for wider consultation with all the stakeholders.

This white paper summarises the literature available globally in public domain and tries to elucidate a set of technical parameters which may be used as a reference to evaluate the quality of output generated from Drone survey for Land Survey purpose. The purpose of this exercise is to initiate discussion on the standards and carry out stakeholder consultation and arrive at final set of standards.

Relevant References:

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2. P-C Lim et al., “Analysis of UAV image Quality using Edge Analysis,” The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-4, 2018.
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4. E. Chang and Y. Park, “Applying Standards of Image Quality:Issues and Strategies,” Korean Journal of Remote Sensing, Vol.36, No.5-2, 2020, pp.907~916.
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15. J. Valente, et al., “Towards Airborne Thermography via Low-Cost Thermopile Infrared Sensors”, Drones 2019, 3, 30.
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17. M. Gogoi et al., “Image Quality Parameter Detection: A Study,” International Journal of Computer Sci International Journal of Computer Sciences and Engineering, Vol. 4, No. 7, Dec 2016.

Potentially Relevant Quality standards/Documents:

1. ISO 4628 series of standards detail the minimum image quality criteria for engineering defect assessments.
2. National Imagery Interpretability Rating Scale (NIIRS) to define and measure the quality of images and performance of imaging systems.

3. DO-160 standards for altitude, temperature, relative humidity, and shock and vibration
4. German standard DIN 18740-8 “Photogrammetric products – Part 8: Requirements for image quality (quality of optical remote sensing data)”
5. ISO 12233 → subset may be applicable

Few Relevant Research Groups & Institutions:

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- ziinconsulting Inc., South Korea.
- Dept. of Geoinformatic Engineering, Inha University, 100 Inharo, Namgu, Incheon, Korea.
- Teledyne Lumenera, 7 Capella Court,Ottawa, ON, K2E 8A7, (613) 736.4077, lumenera.info@teledyne.com.
- Grant Drone Solutions, LLC, Cupertino, California, USA.http://www.grantdrone.com.
- ScoutDI, Leirfossvegen 5D, N-7037 Trondheim, Norway.
- Draganfly INC, Saskatoon, Canada
- KU Leuven, Department of Electrical Engineering – ESAT, Leuven, Belgium.

Super list of Technical Parameters:

S. No.	Parameter	References	Indicative Value for reference purpose only
1.	Pixel array tech.	[6,8]	CCD is preferred with electronic global shutter.

2.	Sensor types	[8,9]	RGB, Thermal and LIDAR Sensing Systems.
3.	RGB Sensor Resolution	[8,9]	12-48 MP
4.	Image Raw (BIT depth)		12-14 Bit Data
5.	Frame Rate	[9]	5 - 60 fps
6.	Communication	[7,11,12]	LTE, next generation 5G cellular systems.
7.	Modulation Transfer Function (MTF)	[7,13,14]	Lens calibration for a certain depth of field, set for multiple distances.
8.	Spatial resolution (lp/mm or lp/cm)		
9.	Lens Resolution		Wide angle 24-60 mm
10.	Ground Sampling Distance (GSD):	[6, 13]	10-60 m; (pixel size * H) / F
11.	Pixel size	[9]	(3.5 x 3.5 to 5.5 x 5.5) um2
12.	Focal length	[9]	4 - 35 mm
13.	Acceptable Flight Height	[11]	200 m to 1000 m.
14.	Latency	[9]	100s of ms; depends on fps.
15.	Flight time	[11]	20 min - 1.5 hour
16.	AI algorithms	[7]	Fully automate inspections and monitor operations.
17.	Compression and decompression (super resolution) Techniques	[9, 6]	H.264 compression

18.	Aperture size; Exposure time;	[16]	Depending on the application, acceptable trade-off of the camera's aperture and shutter speed.
19.	FoV (ratio between lens size and pixel size) [16]. Location tagging. Live streaming. Reconfigurability.		

<u>Some techniques used to estimate Image Quality Parameters [17]:</u>

Technique	**Description**
Modular Transfer Function	It measures how the lens reproduces detail from the object to the image produced by the lens.
Median Filter	It is a nonlinear digital filtering technique. It is used to remove noise from image.
Log Frequency	It measures the contrast of narrow bar that increase logarithmically in spatial frequency. When the image is sinusoidal, contrast is equivalent to MTF.
Uniformity	It measures the drop off in illumination at edges of image, sensor nonuniformity.
Exposure Compensation	It is used to alter exposure from the value selected by the camera for making photos brighter or darker.
MSE	The MSE is the cumulative squared error between the compressed and the original image.
Peak-to-noise ratio	PSNR is used to measure the quality of reconstruction of lossy compression codes such as image compression.
Gray level co-occurrence matrix	co-occurrence probabilities using GLCM for extracting various texture features. GLCM is defined as a two-dimensional histogram of Gray levels for a pair of pixels, which are separated by a fixed spatial relationship.

<u>Relevant Tests and Different Parameter Comparisons:</u>

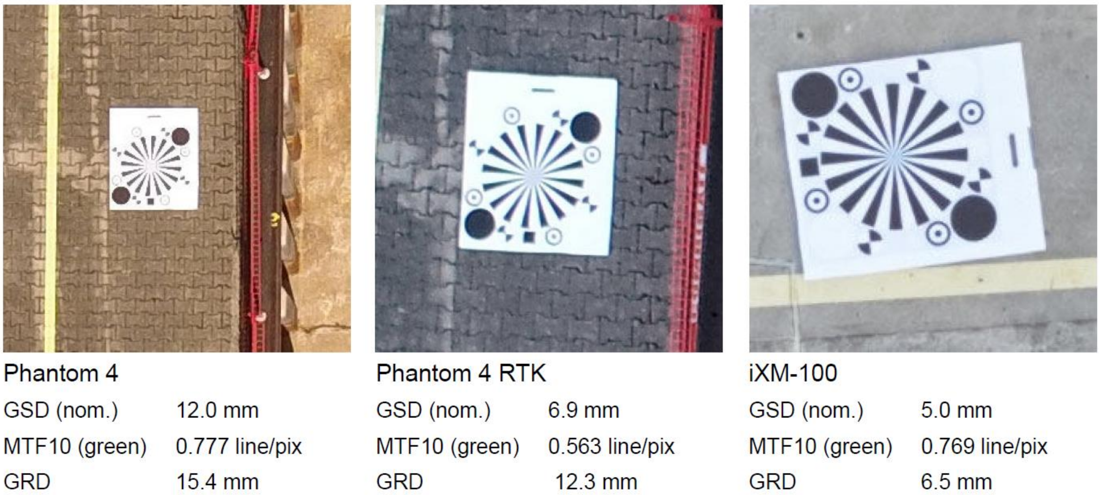

Figure 1. Siemens star image and analysis form Phantom 4, Phantom 4 RTK, and Phase One iXM100-RS. Each image sample is sized 300 x 300 pix. [1]

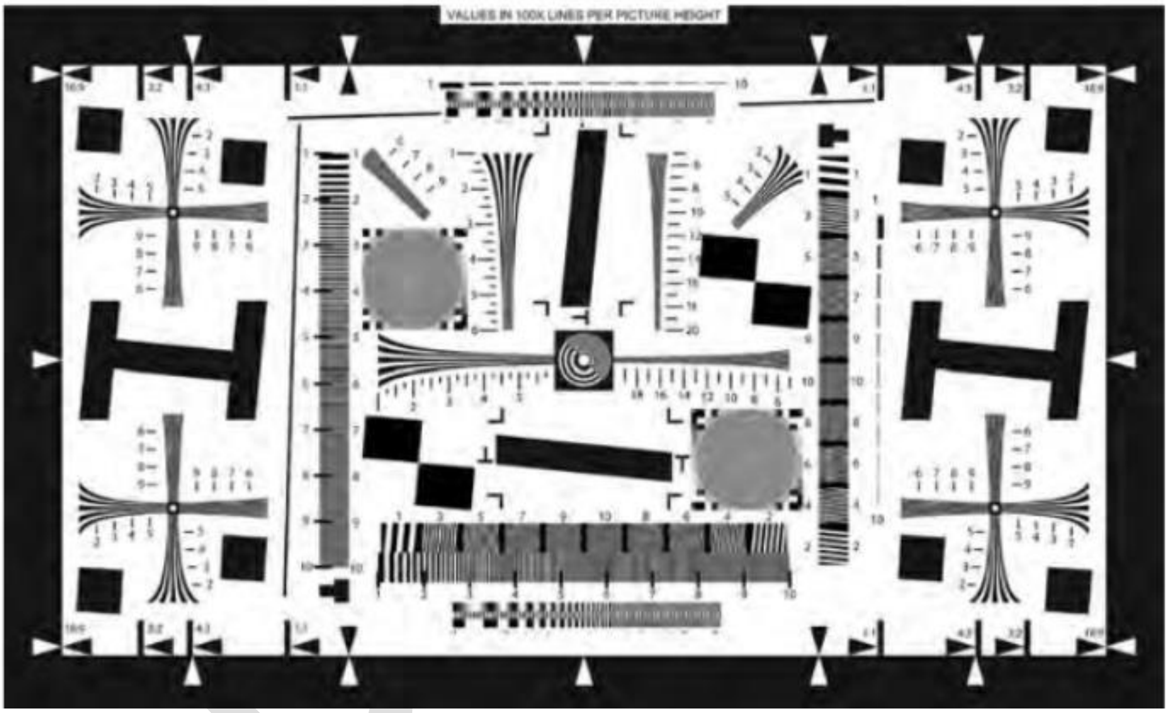

Figure 2. A modified template based on ISO 12233 standard. [3]

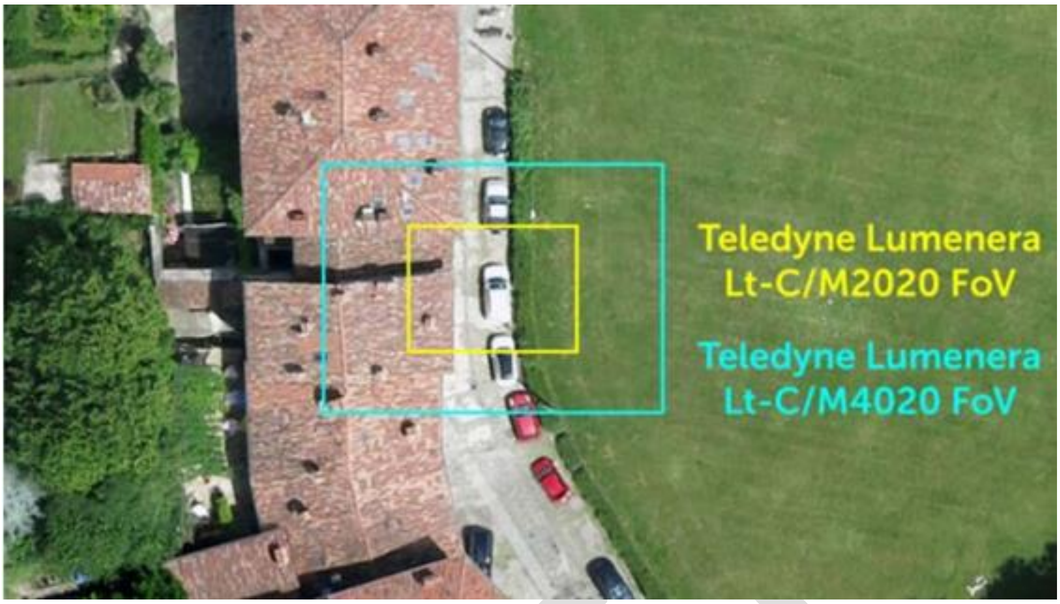

Figure 3. 1/1-inch (lens size/pixel size) sensor gives double FoV as compared with 1/1.8-inch sensor. Camera's Fov is directly linked with the amount of total visual information. [12]

Figure 4. Image skew caused by a sensor with a rolling shutter. [12]

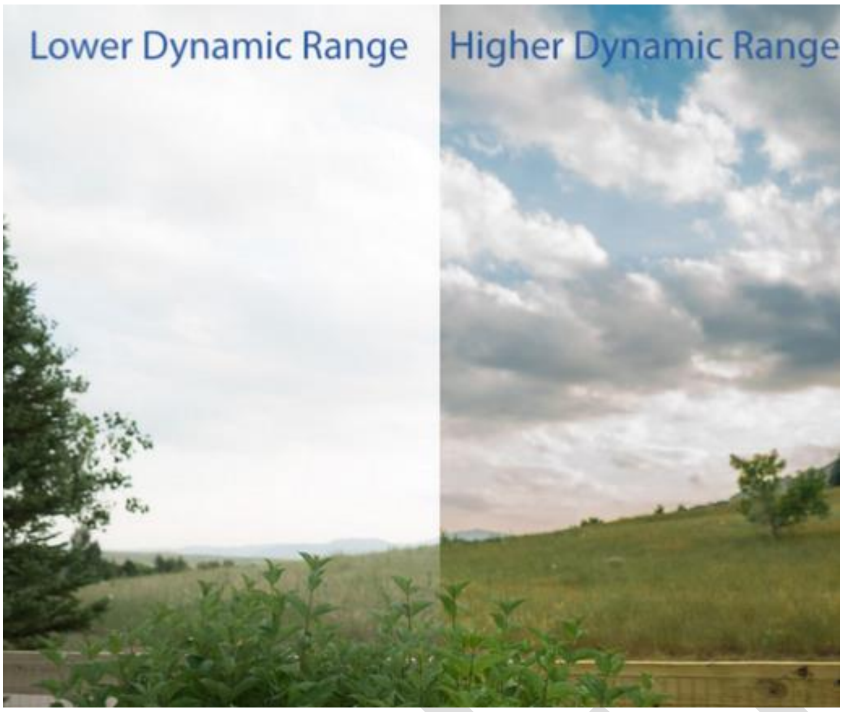

Figure 5. DR: Illustrates the brightest and darkest areas of a scene that can be captured in a single image. [12]

Sample benchmarking from Literature

Table 1. Camera parameters comparison of DJI Phantom 4, Phantom 4 RTK, and Phase one iXM100-RS. [1]

Camera	Phantom 4	Phantom 4 RTK	iXM100-RS
Sensor format [mm] / [pix]	6.17 × 4.55 / 4000 × 3000	13.2 × 8.8 / 5472 × 3648	43.9 × 32.9 / 11664 × 8750
Pixel Count	12 Mpix	20 Mpix	100 Mpix
Pixel pitch [μm]	1.56	2.41	3.76
Focal length [mm] / 35mm equiv. focal length [mm]	3.6 / 20	8.8 / 24	35 / 28 (other lenses available)
Field-of-View (FOV)	94°	84°	76°
ISO range	100-1600	100-12800	50-6400
Shutter speed [s]	8 - 1/8000	8 - 1/2000	Up to 1/2500
Shutter type	Rolling	Mechanical	Mechanical
Focus	fixed at ∞	AF/MF	Fixed at ∞ (for se-lected lens)
Max f-stop	1:2.8	1:2.8	1:5.6
Image format	DNG (raw), JPG	JPG only	IIQ (raw)

Table 2. Camera parameters comparison of Nikon D800E and Xiaomi Yi. [3]

Digital camera	Nikon D800E	Xiaomi Yi
Sensor type	CMOS	CMOS
Sensor size	35.9 x 24.0 mm	6.2 x 4.7 mm
Pixels size on the sensor	4.9 μm	1.34 μm
Number of pixels	36.8 million	16 million
Max. image size	7360 x 4912 px	4608 x 3456 px
Sensor sensitivity	ISO 100 – 6400	ISO 100 – 25600
Max. aperture	F1.8	F2.8
FOV	94.4°	155°
Focal length	20 mm	3 mm
Size	146 x 123 x 81.5 + 87 mm lens	60.4 x 42 x 21.2 mm
Weight	1000 g + 520 g lens	76.6 g

Table 3. Image quality metrics' comparison of Mavic and Phantom sensor system. BRISQUE: blind reference-less image spatial quality evaluator; NIQE: natural image quality evaluator; PIQE: perception- based image quality evaluator. [14]

Image	BRISQUE	Diff	NIQE	PIQE	PIQE Scale
Mavic Pro—original	25,6103		2,0092	21,5645	Good
Mavic Pro—super resolution	38,3286	-12,72%	2,3865	22,3731	Good
Mavic Pro—bicubic	43,2879	-17,68%	3,6959	57,0822	Poor
Phantom 4—original	24,8537		3,6971	15,0224	Excellent
Phantom 4—super resolution	34,8079	-9,95%	3,5549	29,6032	Good
Phantom 4—bicubic	47,0685	-22,21%	5,437	66,4054	Poor

Table 4. Camera parameters comparison of Mavic Pro and Phantom Pro sensor system. [14]

	Camera Model	Resolution	Focal Length	Pixel Size
Mavic Pro SR	FC220 (4.73mm)	8000 x 6000	4.73 mm	0.787 x 0.787 μm
Phantom 4 Pro SR	FC6310 (8.8mm)	10944 x 7296	8.8 mm	1.21 x 1.21 μm

**Note– Figures, Values and charts used in this document are only indicative and for discussion purpose only.

****** Suggestion and comments may please be forwarded on the link mentioned below.**

https://forms.gle/iQygmfAna5qZUwZW9