

SUPPORTED IMAGE-ACQUISITION SYSTEMS

1. Supported photographic cameras

From a photogrammetric point of view, film-based¹ cameras can be subdivided into three main categories: metric cameras, stereo cameras and semi-metric cameras (see Table 1).

	Manufacturer	Type	Image format [mm ²]	Lenses [mm]
Metric cameras	Hasselblad	MK70	60 x 60	60, 100
	Wild	P32	65 x 90	64
	Wild	P31	100 x 130	45, 100, 200
	Zeiss	UMK 1318	130 x 180	65, 100, 200, 300
Stereo cameras	Wild	C 40/120	65 x 90	64
	Zeiss	SMK 40/120	90 x 120	60
Semi-metric cameras	Rollei	3003	24 x 36	15 - 1000
	Leica	R5	24 x 36	18 - 135
	Rollei	6006	60 x 60	40 - 350
	Hasselblad	IDAC	55 x 55	38, 60, 100
	Pentax	PAMS 645	40 x 50	35 - 200
	Linhof	Metrica 45	105 x 127	90, 150
	Rollei	R metrica	102 x 126	75, 150
	Rollei	LFC	230 x 230	165, 210, 300
	Geodetic Services	CRC-1	230 x 230	120, 240, 450

Table 1: Examples from the variety of film-based image acquisition systems

Terrestrial metric cameras are characterized by a consequent optical-mechanical realization of the interior orientation, which is stable over a longer period. The image coordinate system is, like in **aerial metric cameras**, realized by fiducial marks. Amongst those cameras, which are still in practical use, are e.g. the metric cameras Wild P31, P32 and Zeiss UMK 1318. Such image acquisition systems ensure for a high optical and geometrical quality, but are also associated with high prices for the cameras itself. In addition they are quite demanding regarding the practical handling. Beside the single metric cameras in heritage documentation often **stereo cameras** are used. These cameras are composed of two calibrated metric cameras, which are mounted on a fixed basis in standard normal case.

¹ film based = analog

With the use of **semi-metric cameras** the employment of *réseau* techniques in photographic cameras was established in the everyday work. The *réseau*, a grid of calibrated reference marks projected onto the film at exposure, allows the mathematical compensation of film deformations, which occur during the process of image acquisition, developing and processing. Different manufacturers offer semi-metric cameras at very different film formats. Based on small and medium format SLR-cameras systems exist from e.g. Rollei, Leica and Hasselblad. Their professional handling and the wide variety of lenses and accessories allows a fast and economic working on the spot. Semi-metric cameras with medium format offer a good compromise between a large image format and established camera technique.

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Amateur cameras are often used. This often not in a dedicated photogrammetric project, but in emergency cases, where no other recording medium was available or in case of destroyed or damaged objects only such imagery is available. Due to the ongoing destroying of the world cultural heritage it will be necessary also in the future to reconstruct objects taken with amateur cameras.

2. Supported Scanners

The digitization of photographic images offers to combine the advantages of film-based image acquisition (large image format, geometric and radiometric quality, established camera technique) with the advantages of digital image processing (archiving, semi-automatic and automatic measurement techniques, combination of raster and vector data).

Scanner for the digitization of film material can be distinguished regarding different criteria. For example regarding the type of sensor, either point, line or area sensor, or regarding the arrangement with respect to the scanned object as flatbed or drum scanner.

For the practical use of scanners the problem of necessary and adequate scan resolution has to be faced. On the one side the recognition of details has to be ensured and on the other side the storage medium is not unlimited. This holds especially for larger projects. To scan a photographic film with a resolution equivalent to the film a scan resolution of about $12 \mu\text{m}^2$ (2100 dpi) is required. Thus, a scanned image from a medium format film ($6 \times 6 \text{ cm}^2$) has about 5000×5000 pixel. To hold this data on disk requires approximately 25 Mbytes for a black-and-white scan and 75 Mbytes for a colored image. For a scanned color aerial image one would get a digital image of 20000×20000 pixel or 1.2 Gbytes. Even with the constant increasing size and decreasing costs for computer storage medium, this is a not to underestimate factor in the planning of a project.

² Micrometer (μm) = millimeter (mm)

Two different types of scanners are typically used: **high-resolution photogrammetric scanners and desktop publishing scanners.**

The **photogrammetric scanners** are typically flatbed scanners, which have a high geometric resolution (5-12.5 μm) and a high geometric accuracy (2-5 μm). Currently there are just a few systems commercially available, which are offered mainly by photogrammetric companies. The **desktop publishing scanners** (DTP) are not developed for the photogrammetric use, but they are widely available on the market at low cost and they are developed and improved in a short time interval. DTP scanners have typically a scan size of DIN A4 or A3 with a scan resolution of 300-1200 dpi. The geometric resolution of these systems is about 50 μm . Despite this technical reduction compared to photogrammetric scanners, this scanners, which are low cost and easy to handle, can be used for photogrammetric purposes. This holds especially for calibrated systems, where geometric accuracy in the order of 5-10 μm is feasible.

Another possibility for the digitization and storage of film material offers the **Photo-CD system**. Small and medium format film can be digitized in a special laboratory and stored on CD-ROM. The advantage of such a system is the inexpensive and easy digitization and convenient data archiving. On the other side the scanning process can not be controlled or influenced and the image corners are usually not scanned. Thus the interior orientation of an image is nearly impossible to reconstruct.

3. Supported digital CCD cameras

The development of digital image acquisition systems is closely connected to the development of CCD sensors. The direct acquisition of digital images with a CCD sensor holds a number of advantages, which makes them interesting for photogrammetric applications:

- direct data flow with the potential of online processing,
- high potential for automation,
- good geometric characteristics,
- independent of the film development process,
- direct quality control of the acquired images,
- low-cost system components.

For photogrammetric applications mainly **area-based CCD sensors** are used. These sensors are produced for the commercial or industrial video market. Area-based CCD sensors are used in video cameras as well as in high resolution digital cameras for single exposures (still video cameras). Furthermore there are specialized systems which use a scanning process for the image acquisition.

Today more and more **high-resolution digital cameras** are used. Such cameras can be described as a combination of a traditional small-format SLR camera with a high resolution CCD sensor replacing the film. The digital image data is stored directly in the camera body. In the photogrammetric community very much know representatives of

this type of camera are distributed from Kodak/Nikon under the Name DCS x20 and x60. They offer resolutions of 1524x1012 pixel and 3060x2036 pixel respectively. In addition various manufacturers offer camera systems with a resolution of about 2000x2000 pixel. The main advantage of such systems is the fast and easy image acquisition. This is achieved due to the fact that image acquisition, A/D conversion, storage medium and power supply is combined in one camera body. This allows to transfer the images immediately to a computer and to judge the quality of the acquired images or to directly process them.

In Table 2 a few examples from the digital image acquisition systems proposed on the market. This compilation is naturally incomplete. A good overview on digital image acquisition systems is nowadays available on the Internet pages of the different manufacturers.

Manufacturer	Type	Number of pixel (HxV)	Image format [mm ²]	Approx. Price €
Zoom digital cameras:				
Fuji	FinePix S602	2048x1536	Super-CCD	1000
Minolta	Dimâge 7i	2560x1920	CCD 2/3"	1500
Nikon	Coolpix 5700	2560x1920	CCD 2/3"	1700
Olympus	Camedia E-20P	2560x1920	CCD 2/3"	2700
Interchangeable single lens reflex digital cameras :				
Nikon	D100	3008 x 2000	CCD	3200
Fuji	FinePix S2 Pro	4256 x 2848	Super-CCD	3000
Canon	EOS D60	3072 x 2048	Cmos 22.7 x	3350
Sigma	SD9	2263 x 1512	X3 Cmos	-
Canon	DCS760	3032 x 2008	CCD 27.7 x	-

Table 2: Examples of digital image acquisition devices