



IMAGERY STANDARDS

Photographic Mission

Forward overlap in the line of flight shall average not less than 57% or more than 62% at the mean elevation of the terrain, unless otherwise specified. Individual forward overlaps shall not be less than 55% or more than 68% excepting the situation where in a forward overlap in areas of low elevation must exceed 68% to attain the minimum 55% forward overlap in adjacent areas of higher elevation. Wherever there is a change in direction between two flight lines (other than between adjacent parallel flight lines) junction areas between the adjoining flight lines shall be covered stereoscopically by both lines. Side Overlap between adjacent parallel flight lines shall be 30% +/- 10% at the mean elevation of the terrain. In addition, any point on the flight line as flown shall not deviate from the flight plan location by a distance greater than 10% of the width of coverage of the photograph. Departures from flight heights required to produce the desired photo scale shall not exceed -2% or +5% unless changed by Air Route Traffic Control Centers. Changes in the course of the aircraft between successive overlapping photographs within a flight line shall not exceed 3 degrees. While exposing aerial photography, the camera shall be compensated for crab of the aircraft, with a resultant error not exceeding 3 degrees. The tilt within a single frame shall not exceed 4 degrees nor shall the difference in tilt between two consecutive overlapping frames within a flight line exceed 4 degrees. The average tilt for all negatives of the same nominal scale shall not exceed 1 degree. The combined effect of aircraft course corrections, crab and tilt shall result in an apparent crab not greater than 5 degrees on successive photographs. Apparent crab is defined as the angle between a line joining fiducial marks in the direction of flight and the line between the indicated principal point and the conjugate image of the indicated principal point of the adjacent photograph within the same line of flight.

AERIAL FILM AND IMAGE QUALITY

Aerial Film

The type of film to be used shall be unexpired and have a dimensional stable polyester base. Color and panchromatic emulsions shall be sensitive to the entire visible spectrum with an extended red sensitivity. Color infrared and black and white infrared emulsions shall be sensitive to the visible and near infrared spectrum from 400 to 900 nanometers. Extreme care shall be exercised to insure proper exposure to minimize vignetting due to differential exposure. This differential shall not exceed that which would result from a basic 1/3 stop difference in exposure.

The conditions of the film stock to be used shall be such that when the unexposed film is processed:

- It shall be free of stains, discoloration, or brittleness that can be attributed to aging or improper storage: and
- The base-plus-fog density for all negative films and the minimum-density for all color reversal films shall conform to the manufacturers predicted density levels.

Suggested Aerial Films

Kodak	2407	Black and White Film or Afga	Pan 80	Black and White Film
Kodak	2427	Color Positive Film or Afga	Chrome 200	Color Positive Film
Kodak	1443	Color Infrared Film		

DELIVERABLE PRODUCTS

Aerial Film

The exposed/processed aerial film should be delivered in accordance with the stipulations of delivery schedule and delivery address. All flight maps used for the acquisition should accompany the aerial film, as an aid for the quality control inspection. Each processed roll or partial roll of aerial film shall be kept in roll form, on the spool, and in the plastic container supplied by the film manufacturer. Rejected exposures shall not be removed from any roll. The aerial film shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address.

Contact prints

Two sets of contact prints shall be made on an automatic dodging printer using medium weight resin-coated paper for which ink and pencil can be used on both sides. The contact prints shall be delivered to the owner in accordance with the contractual stipulations of delivery schedule and delivery address. The photographic emulsion shall be of fine grain and have a suitable light sensitivity range and contrast for the making of prints from the aerial film exposed under this contract. Outdated materials shall not be used. Processing, including exposure, development, fixation, washing, and drying of all photographic materials, shall result in finished photographic prints having a fine grain quality, a normal, uniform density, and such tone and contrast that all photographic details shall show clearly within the dark and light tone areas as well as in areas with intermediate tones. Adequate grades of contact paper and proper laboratory procedures shall be used to achieve the best prints possible. Excessive variance in tone or contrast between adjoining prints shall be cause for rejection. Photographic prints shall be trimmed as specified by the user. When trimmed always leave the camera fiducial marks, GPS and other data recorded in the border of each image. Prints showing fiducial marks of inadequate clarity and definition, or prints omitting fiducial marks, shall be rejected. All prints shall be clear and free from chemical stains, blemishes, uneven spots, air bells, newton rings, halo affects, light streaks or fog, and other defects, which would, in the opinion of the owner, interfere with their intended purpose. Hard copy prints shall be delivered to the owner in a smooth, flat and usable condition.

Digital Image Files

The selected project images shall be scanned at 15 microns or less, uncompressed .tif files, used in the Photogrammetry mapping process. The images shall be delivered to the owner imaged on CD-R or DVD-R diskette.

English

NDOT Map Type	Large	Intermediate	Small	Small
Film Scale	1"=300'	1"=600'	1"=1000'	1"=1200'
Flying Height	1800'	3600'	6000'	7200'
Scan Resolution	<15 micron	<15 micron	<20 micron	<20 micron
Scanned Ground Pixel Resolution	.18'	.33'	.79'	.94'
Ground Pixel Resolution Of Orthophoto	.25'	.50'	1'	1'
Mapping Photo File Size Scanned at 12.5 micron	350 MB B/W 1.05 GB Color	350 MB B/W 1.05 GB Color	350 MB B/W 1.05 GB Color	350 MB B/W 1.05 GB Color

Metric

NDOT Map Type	Large	Intermediate	Small	Small
Film Scale	1: 3600	1: 7200	1: 12,000	1: 14,400
Flying Height	550m	1100m	1830m	2200m
Scan Resolution	<15 micron	<15 micron	<20 micron	<20 micron
Scanned Ground Pixel Resolution	.05m	.11m	.24m	.29m
Ground Pixel Resolution Of Orthophoto	.08m	.15m	.33m	.33m

Micron to D.P.I.

$25,400/\text{Microns}=\text{D.P.I.}$

Example: $25,400/15 \text{ micron} = 1693 \text{ D.P.I.}$

Ground Pixel Size

$\text{Photo Scale Ratio} / \text{D.P.I.} / 12 = \text{Ground Pixel in Feet}$

Example: $3600 \text{ Photo Scale} / 1693 \text{ D.P.I.} / 12 = .18 \text{ feet}$

IMAGE SCANNING STANDARDS

Scanning Instrumentation

A photogrammetric grade-scanning device will be used to create uncompressed TIFF standard images. It should be located and operated in a thermostatically controlled, dust free environment with a stable power source.

Acceptable Aerial Films

When the aerial film is scanned the scanner must not physically come in contact with the film while the film is in motion. The introduction of scratches to the aerial film by the scanner will be unacceptable and cause for the rejection of the scans as well as possible penalties at the discretion of the Nevada Department of Transportation (NDOT). Unless otherwise specified, all digital aerial imagery will be produced from negative or color transparency film rolls and **not film diapositives**.

Scanning shall be carried out only from first generation transparent originals or aerial film.

Scanner Calibration

Any scanner to be used for the scanning of aerial imagery must be calibrated at least annually and provide a calibration report signed by the manufacturer's technician. The report must show that the scanner maintains a geometric accuracy of not more than five (5) microns RMSE at the scanner's plate scale, and be capable of resolving 256 levels of gray or of each color band. A minimum of 20 well distributed points shall be read on a calibrated glass grid plate of accuracy of one micron or better during the geometric accuracy test. It is not acceptable to post process the scan data to achieve this requirement. The calibration report shall show the manufacturer's name, model number, serial number, date of the calibration, individual readings of grid points, rectangularity, and calculated RMSE value for the instrument. A copy of the technician's service report showing the scanner's camera calibration must be sent if requested by NDOT.

Scanning Requirements

In order to maintain consistently high quality image scans certain procedures shall be carried out during the scanning process. The following instructions are based on normal scenes and do not apply directly to scenes with skewed tonal representations (i.e. Images with predominant snow, sand, water, or shadow areas). The minimum and maximum densities of the images shall be captured without clipping and without leaving unused bins on the ends of the histogram. The output pixel values shall be proportional to the Density of the media being scanned.

Image compression will not be applied during the scan process.

Scan Resolutions

Image scans produced to support digital orthoimagery must be scanned at a finer resolution than the intended orthoimage resolution. Resampling original image scans to a finer resolution is not permitted.

Unless otherwise specified, the scan resolution – or ground sample distance (GSD) used in the production of digital aerial imagery will conform to the standard identified in the following table.

Photo Scale	Scan Resolution	GSD
1: 3,600	12.5 µm or less	0.045 m = .18'
1: 7,200	12.5 µm or less	0.090 m = .36'
1:12,000	12.5 µm or less	0.150 m = .79'

Radiometric Accuracies

The scanner must be capable of scanning from the original negative or color transparency. The conversion from the original image to digital pixels shall be carried out proportionally to the density of the original. Representation of the tones proportionally to the transmissivity of the original will not be accepted. When a standard photographic step wedge is scanned, the resulting tones shall be within 10 pixel units from their calculated position based on the steps density. NDOT reserves the right to request sample scans of a calibrated step wedge in order to verify compliance. The calculated pixel value will be calculated as follows.

$$\frac{(Density - D_{min})}{(D_{max} - D_{min})} * 255 = Pixel Value \pm 10 \text{ pixel units}$$

For example if a step wedge is scanned with a range of 0.15 to 1.30 density values representing logE (exposure), the following pixel values will result (± 10 pixel intensity units)

Density	Pixel Value
0.15	255 (bright)
0.30	233
0.45	200
0.60	166
0.75	133
0.90	100
1.05	66
1.20	33
1.30	0 (dark)

Images of "normal" scenes will typically display a Gaussian distribution of pixel values with the mean centered on pixel value 127. There should be no unusual spikes of data, or gaps in individual pixel bins

Density Ranges

Scanners must be capable of scanning original imagery with a density range (Dmax - Dmin) of at least 1.3 without resulting in missing pixel bins or gaps. Post processing to merge bins is not acceptable unless resolution is reduced by a factor of at least 40% at the same time (ie. Scan at 11 microns and resample to 15 microns). If originals are provided with a density range greater than 1.3 or greater than the instrument's effective density capability (if greater than 1.3), NDOT shall be informed and a proposal offered for the solution of the problem. A final solution shall be reached in consultation with NDOT.

Image File Naming Convention

Image scans will be named with NDOT flight number, under bar, frame #'s, as shown in the examples below:

2785_0103.tif
2785_0104.tif
2785_0105.tif