DSW600 - Digital Scanning Workstation

Overview

The DSW600 was designed to build on the successful design of the DSW200/300/500, with four principal objectives:

- Improved imagery and productivity through the availability of project-based optical resolutions
- Use of the basic technology from the DSW200/300/500, including moving stage, stationary camera, and leading edge CCD technology
- Higher performance options than the DSW200/300/500 such as, support of new 12-bit CCD cameras for extended radiometric sensitivity
- More modern components and reduced costs

Product Description

Leica
Geosystems

Key Features

Introduction

The Leica DSW600 Digital Scanning Workstation is based on its predecessors, the DSW300 and DSW500. The DSW600 performs precision scanning of color or black and white negatives or diapositives, on either cut or roll film, to provide digitized image data to digital photogrammetric workstations running SOCET SET®, ERDAS IMAGINE® software or other digital image systems.

The system consists of the following principal components:

- Improved radiometric performance using 12 bit digital sensor
- Increased performance through improved light source
- Increase productivity by ease of optical pixel size changing and calibration
- Improved reliability and quality improvements

The XY stage is of comparable quality and provides sturdy, independent positioning with respect to the sensor axes. It is based on a stage-on-stage design, which provides stable, trouble free performance with little periodic maintenance. Mounted on the base are the optics and 12 bit digital sensor used to digitize the transparencies. The optical path has been minimized to increase performance. No beam splitters or folding mirrors are used. The light path is straight, going directly to the digital sensor. The stage and optical path are mounted inside a specially designed enclosure, which prevents dust and dirt from accumulating on the film or extraneous light from entering the system during scanning. Illumination is provided by a liquid optic feed, thus keeping the stage and optical path free from unwanted heat sources. The following sections describe the characteristics of the major components of the DSW600.

Hardware Characteristics

- **Basic Design:** The DSW600 has at its center an extremely rigid base plate, manufactured as precision casting. This is supported on a base frame, furnished with casters and stabilizers (leveling screws). On the base plate are mounted precision steel rails; these derive their flatness from the base surface on which they are mounted and a jack screw approach is taken to ensure straightness before the rails are screwed tight in their final position. The Y stage runs on the lower set of rails and the X stage runs on a pair of similar rails mounted on the Y stage. Both stages are milled from aluminum.

  A backlit panel mounted on the lower stage enables the operator to view a section of the film, for example, to select a particular exposure for scanning.

  Two sets of stanchions to carry the film spools are mounted on the X stage. The distance between the stanchions within each pair can be varied to accommodate different film widths. A simple spring-loaded mechanism enables the film spools to be loaded and unloaded. Powerful DC motors are fitted to drive the spools, strong enough to handle both fast and slow driving of films up to 500 feet (152 m) in length. A rotary encoder and a pinch roller are used to measure the travel of the film. All rollers in the film transport are manufactured from Delrin plastic and are in contact with the edges of the film only, not all across the format to minimize any tiny marks that could conceivably occur during scanning.

  An automated motor and cam arrangement raises and lowers the glass cover plate under software control to permit roll film to be transported. For cut film, the operator raises and lowers this plate manually, at which point it behaves like a hinged lid.

- **Input Media:** The stage accepts film transparencies, as roll film or cut film, or glass plates of any thickness. The medium should be mounted emulsion down. The scanning format accommodates images more than 260 mm square (10.2 x 10.2 inches). Input transparencies can be color or black and white and can be positive or negative.

- **Servo Drives:** The drive mechanism is a friction drive mechanism that provides excellent performance and requires little maintenance. The stiffness of the stage drives and the data rates to the servos are such that smooth, precise stage motion is provided at all speeds. This design has been successful on all DSW models for the past 10 years and the DSW600 drive is upgraded to that used on the DSW300/500. The stages are moved by high performance DC servo motors and their travel is measured by linear encoders, giving a positional resolution of 0.5 µm (0.0005 mm/0.00002 inch). The movement is controlled by a feedback loop in the motion controller mounted in the base structure. The maximum slew rate is approximately 100 mm (3.9 inches) per second.

- **Stage Accuracy:** The resolution of stage positioning at any point is 0.5 µm. The accuracy is typically 2 µm (0.002 mm/0.00008 inch) root mean square (rms) or better on each axis, based on computer calibration and compensation. Stage calibration is provided via automated grid plate measurement and is required infrequently.

- **Light Source and Optics:** The illumination system provides uniform illumination from above over the field of view of the camera. The DSW600 uses a xenon type lamp, like that favored in the DSW200/300 for its high color temperature and efficiency. The low voltage flashlamp (strobe) model, however, has replaced for the DSW500 and DSW600 models the higher voltage continuous arc lamp used in these prior scanners. The strobe source voltage, number of flashes and flash frequency are all under host computer control in order to provide a highly repeatable, variable range of intensity to suit any film type. The lamp source is first passed though a color filter wheel, then condensed into a liquid light guide and finally piped into an integrating sphere diffusing system above the film. The software controlled color filter wheel (a Geneva wheel is used to give exact, reliable 90º rotations for panchromatic and three color bands) has been improved over that in the DSW300, by reducing size and mass, as well as allowing higher speed. Color filters with adjustable light control are used to obtain balanced color film digitizing. The full range of light intensity is now completely under software control. The manual aperture disk/wheel system of the DSW200/300 has been eliminated in the DSW500/600. The use of the pipe optic ensures that the heat/noise associated with the light source and filter wheel can be isolated well away from the stage assembly to avoid temperature variations and vibrations.

The extremely even illumination of the integrating sphere has been chosen for the DSW600. As with the DSW500, its size has been reduced in diameter from that in the DSW200/300 for increased light output. The output port size has also been increased by about 50% to support faster scanning at larger pixel sizes or with larger array cameras.

A 120 mm color-corrected lens has been selected to image the film on to the camera sensor. This lens provides greater light throughput and lower distortion than that used in the DSW200/300.A 80 mm lens is avalible as an option for even higher resolution for special applications

- **Digital Camera:** A new 12-bit, large area array camera is standard on the DSW600. It provides better performance than the high end DSW500 with the 6.3i camera.
- **Full Fill Factor Digital Sensor:** The DSW600 uses full-fill factor digital cameras and associated optics for image digitization. These high resolution cameras are at the leading edge of modern technology and are among the very best area array CCD cameras on the market. The exciting aspect of the technology supported in these cameras is pixel full fill factor. This means that by novel design of the sensors themselves and the supporting electronics, 100% of the area of each of the pixels is responsive to light. The corresponding figure for earlier technologies was around 50%. Throughput is high, approximately 40MB/sec. The physical size of each array element in the CCD is 10 x 10 µm (0.01 x 0.01 mm). Another advantage of the camera is that these pixels are square and accurately positioned. Between the CCD array and the image is an optical system and the physical pixel size at the film plane is adjustable in the range 4.5-22 µm (0.0045-0.022 mm/ 0.00018-0.00087 inch). With the optional 80mm lens, pixel sizes as small as 3µm are possible. Imagery is scanned and may be output at any pixel size selected by the user, up to 256x the raw pixel size. The precise CCD image geometry and low distortion optics provides an essentially distortion free image.

  Thus the square pixels in the camera provide 100% light sensitivity over the pixel area. The output of the CCD sensor is digitized by means of a PCI-bus frame grabber board with 12 bits per pixel of radiometric resolution. This provides sufficient dynamic range to handle both color and black and white films of large density ranges. The uniformity and wide radiometric range of these pixels aids the measurement processes used in photogrammetry. The host computer allows processing of the 12-bit digital signal into a typical 8 bits per band digital image. It is also possible to output 12-bit grayscale images (2 bytes per pixel).

  The resolution of the digitizing system is a combination of the resolution of the optics and the resolution of the CCD camera system and associated image processing system. The optics used in the light path provide the required resolution for the pixel size. The optical resolution of the digitized image is approximately 40 line pairs per millimeter (lp/mm) when using a 12.5 µm (0.0125 mm) image pixel size (33 lp/mm at 15 µm and 100 lp/mm at 5 µm).With the optional 80mm lens, the optical resolution is approxometly 180 lp/mm show using a 3mm image pixel size.

  For customers for whom very high resolution scanning is a priority, the DSW600 can be supplied to special order with a second lens which extends the smallest pixel size to 4 µm (0.004 mm/0.00016 inch), at which an optical resolution of 125 lp/mm is usually obtained during calibration.
- **User Control Panel:** There is a user control panel with 2 rows of 16 buttons and a small LCD panel with 4 rows of characters. These are used to input user commands, run diagnostics, etc. This panel contains a small computer circuit to control the LCD display, read the push button switches and communicate with a DOS-based communications computer card. The panel may also be used for manual movement of the stage and roll film transport.
- **Power Supplies and Electronics:** There are four power supplies, one giving 5V and 12V, one giving 40V for the motors, one giving 24V for the digital camera, and the fourth supplying 24V for igniting the xenon flashlamp up

to 1KV.

There are three main groups of circuit cards: a DOS-based computer card for input, output and communications; a motion controller card set for closed-loop servo control, incorporating into one compact unit the real-time logic, control and software functions associated with servo motion; and a servo amplifier assembly, which controls the four motors (X stage, Y stage, two for film roll) and has the option of controlling two more in the future (lens and camera motions for automated variation of pixel size). Commands to the servos and linear encoder feedback are sampled or updated 400 times per second to ensure smooth, vibration-free performance. Communication between the motion controller and the control computer takes place over a standard RS-232C serial line interface. In addition there is a small circuit card for functions such as color wheel logic, lamp operation and motor driver circuits. Another small card contains the circuitry associated with the system film tension control described above.

The DSW600 runs at 3.2 amps on 110V (1.6 amps at 220V) and the peak load with a 500 foot film roll is calculated to be 6 amps.

- **Outer Housing:** The stylish skins of the DSW600 are made of two main parts. The pedestal around the base structure is made from pressure formed plastic, and the top housing, fiberglass. The pedestal is charcoal in color, the top housing dove and the colored inserts Leica red. The product name is in black and the company logo in red and white. There is one LED to indicate servo power. The top housing has one large lid, for the loading and unloading of roll film or cut film or for viewing the position of a film roll.
- **Tools and Accessories:** Standard system delivery provides all special tools and accessories required for routine maintenance, lubrication and calibration, including a precision grid plate for checking stage accuracy and special filters for calibration of sensor radiometric response.

Host Computer and Software

- **Host Computer:** Intel Pentium 4 processor running the industry-standard Windows 2000 operating system.

  The minimum required Windows 2000 host is a Dell Computer Corporation (or similar) dual processor Intel Pentium Xeon P4 running at 1.4 Ghz, 1GB RAM, 20 GB hard drive, CD-ROM and 1.44 MB floppy. Graphics must be provided by an AGP card with resolution of 24-bit, 1152x900. A 19-inch or larger color Trinitron monitor is recommended. Other forms of storage, for example optical disk, DAT or DLT, may be chosen as options.

- **Operating System, User Interface and Application Environment:** The PC operating system must be Windows 2000 with service pack 2. Application software is the Leica Geosystems SCAN software.

  Standard applications software is supplied as described in the following sections. The applications software is GUI-based and promotes a consistent "point and select" operation in all functionality. The DSW600 software has been enhanced to include fully automated interior orientation, roll film scanning operations and optional image filtering.

- **Photo/Stage Orientation (Interior Orientation):** This function is used to establish a precise photo-to-stage coordinate transformation (interior orientation) for the input film placed on the digitizer stage. The transformation is based on the measurement of up to eight fiducial marks. It provides for transformations from a simple scale and rotation to a trapezoidal fit. The program assists the operator in the location of the fiducial marks, automatically slewing to their approximate positions. Real-time light control and zooming of the image is available to assist the operator in pointing (measuring a sub-pixel location). The user can easily store the coordinates of the fiducial marks with the other camera calibration data. When the fiducial marks on the first image from a particular camera are measured, their image patches are stored as templates to enable automated interior orientation of subsequent images acquired by the same sensor, essential for autonomous operation with roll film.

  The ability to perform an interior orientation on the photograph prior to digitization allows the user to select precisely a sub-region of the image for scanning by means of photo coordinates. This permits the user to reduce image size and still have geometric accuracy of the resulting pixels in fiducial space, thereby saving valuable production time by not having to scan the entire image. The software uses the fiducial coordinates from the camera database to drive the stage to the approximate positions, thereby speeding up the measuring process.

- **Stage Calibration:** A calibrated grid plate, supplied with the system, is utilized to determine a table of corrections to be applied in real-time to the stage coordinates to achieve the final stage positioning accuracy of the system. It proceeds automatically once the operator has manually pointed to the first grid intersection. The grid intersections, spaced at 20 mm intervals, are driven to and measured automatically, using the correlator mode of operation to point precisely to each grid intersection. When all grid intersections have been measured, a table of corrections is computed. Grids with 10 mm spacing can be used to enhance system precision and may be purchased as an option.

There is also has a stage verification mode where the current calibration can be checked. In this mode, the operator indicates the spacing of the grid intersections to use in the verification (every intersection or every other intersection). The system then proceeds to step through the grid plate, measuring the intersections automatically with the current calibration applied. It then computes the root mean square error of the measurements made and displays this along with the actual error at each point on the user interface monitor.

- **Sensor Calibration:** This function performs both a geometric and a radiometric calibration of the CCD sensor. For the geometric calibration, a calibration grid is utilized to determine actual pixel size (horizontal and vertical size independently) and a transformation between the sensor and the stage coordinate system. Once the operator has centered the grid intersection on the measuring mark, the grid intersection is moved and measured automatically at 25 locations within the sensor field of view, using the same precise correlator mode of operation. The known stage position and the measured pixel coordinates of the nine locations are used to determine the exact pixel size, as well as the transformation between the pixel coordinate system and the stage coordinate system.

  For the radiometric calibration, the function uses four four-color image patches and time dependent dark frame captures to determine a set of bias and gain adjustments for each pixel in each color band to correct for variations in radiometric response over the entire sensor area as well as time of exposure. These bias and gain adjustments are saved in calibration files for later application to the image patches captured during digitization.

- **Image Scanning**: Image scanning, or image digitizing, as it is sometimes called, utilizes the CCD camera to convert the image transparency into digital data for use on digital photogrammetric workstations. A large capacity hard drive is provided as standard equipment for archiving of scanned imagery. Other output devices can be provided. In standard configurations where the DSW600 is an element of a larger system, imagery can be transferred electronically over a local network. Several image formats are supported, both on-the-fly and off-line, including plain raster (BIL), Sun raster, VITec, tiled TIFF, tiled TIFF JPEG and NITF JPEG compressed. An embedded set of minifiication levels may be optionally stored in the tiled TIFF formats. Where necessary, information on the versions of these formats being supported is available.

  The scanning function enables the operator to select the whole or a portion of the input photograph and generate a seamless digitized image representing the film. In addition to specifying the area to be digitized, the operator may also adjust the final output pixel size by resampling to obtain image scans at lower resolutions. Tone transformations may also be chosen to optimize image display on the target softcopy workstation. The name of the file is all that remains to be specified. Once the digitization process itself is initiated, it proceeds automatically, with no operator intervention required, until the entire area specified has been collected. The final output is a binary file containing a digital copy of the photo along with an ASCII file describing its geometry.

  Output speed depends on the computer and camera selected but can exceed five million pixels per second to the hard disk. In the case of roll film, scanning can proceed automatically from one image to the next and images can be named in accordance with user defined schemes.

- **Support Programs:** In addition to the applications programs described above, the software package includes hardware diagnostic routines for the computer, measuring stage, peripherals and graphics processor for use in diagnosing malfunctions. A powerful viewing program is also included to check the appearance of the completed scanned image.

General Physical Requirements

- **Temperature:** The system should be installed in a normal air-conditioned office environment. The operating temperature range is 21 ±2° C; however, no equipment failures occur over the range 17-25° C.
- **Humidity:** The operational relative humidity range is 40-70%. The maximum relative humidity is 90%.
- **Vibration:** Externally induced floor vibrations must be less than 0.01g at all frequencies.
- **Floor Space and Carrying Capacity:** The equipment can be installed in a 1 x 2 meter area with a floor carrying capacity of 800 kilograms.
- **Electrical Power:** The electrical supply is 60 ±2 Hz, 110V or 50 ±2 Hz, 230V nominal. The normal configuration requires a single independent 20 amp circuit.

Dual Use as a Digital Photogrammetric Workstation

It is possible to configure the DSW600 host with dual functionality, i.e. so that it operates as both a scanner and a digital photogrammetric workstation. The characteristics of the Leica Geosystems digital photogrammetric workstations, together with their SOCET SET® and applications software, are amply documented elsewhere. Suffice it to say that SOCET SET® can run on the DSW600 host with appropriate hardware, for image roaming and stereoscopic viewing.

An especially interesting application of this dual functionality is with the MULTI-SENSOR-TRIANGULATION and APM SOCETs for automated triangulation and Leica Geosystems' ORIMA package for bundle adjustment and analysis. Users who wish to scan and triangulate imagery on the same workstation may do well with such a configuration. All other digital photogrammetric functionality may be achieved, through addition of further modules of SOCET SET® and perhaps applications software, for feature extraction and editing.

Documentation

Instruction manuals are supplied giving detailed operating procedures as well as hardware description and maintenance instructions. In addition, the normal system hardware and software documentation provided with the computer and operating system software is included. A training manual is also available.

What's New About the DSW600?

- A new camera and lens preasion rail mount replaces the cylinder mount in the DSW200/300/500. Moveable and lockable camera and lens carriages on this rail provide the means for operators to change optical conjugates and adjust focus easily. Rotation adjustment or platten leveling is not required as in the DSW500. This results in the continuous range of pixel sizes between 4.5 and 22 µm achievable in 30 minutes or less including all software calibrations. An optional lens provides resolution down to 4 µm.
- A new optical filter is mounted on the integrating sphere to provide a more directed illumination, less subject to scattering in the image. Improved resoulution and radiometry is the result.
- Performance and flexibility are superior to the last generation top-of-the-line DSW500 with 6.3i camera. Optical pixel sizes can be changed on a project or roll film basis to obtain maximum speed from the scanner. Scan times for the DSW600 are 10 percent faster than for the 6.3i DSW500 at the same pixel size.
- A new camera with 12-bit A/D quantization results in improved histograms and a broader choice of tonal adjustments than the 10-bit range of the DSW200/300/500.
- Improved component enclosures, such as the light and electronics units, allow easier access for maintenance as well as future upgrades to components.

Specifications

BASIC TECHNOLOGY	Moving stage, stop and stare, stationary CCD array
XY STAGE	
Geometric resolution	0.5 µm
Geometric precision	<2 µm rmse on each axis
Scanning format	In excess of 260 x 260 mm
Speed of stage travel	Maximum 100 mm/second
Roll Film Transport	
Maximum spool diameter	194 mm (7 5/8 inches)
Film length	Maximum 152 m (500 feet)
Film width	Variable, 70-240 mm
Frame advance speed	>0.3 m/second
Rewind speed	5 minutes/500 foot (152 m) roll
SCANNING OPTICS AND ELECTRONICS	
Light source	Xenon flash lamp
Optical train	Color filter wheel, liquid optic pipe, integrating sphere
Digital camera	12-bit area array sensor
CCD array	2000 x 3000
Sensor pixel size	10 µm
Lens	Schneider 120 mm, color-corrected
Image pixel size	4.5-22 µm continuously variable with a 4 micron option
Optical resolution	33 lp/mm @ 15 µm, 40 lp/mm @ 12.5 µm, 100 lp/mm @ 5 µm
Radiometric range	greater than 2.5 but recording of densities higher than 3.0 possible with longer exposure times
Radiometric resolution	0.01D at 1.0D
ELECTRICAL POWER	
Input power	110/220V AC, 50/60 Hz
Maximum load	6 amperes
DIMENSIONS	
Size	1238 x 1003 x 1175 mm width x depth x height
Weight	288 kg (633 lb.)
HOST COMPUTER	
Workstation	Pentium 4 dual processor (Xeon chipsets)
RAM	1GB
Hard disk minimum	20 GB IDE 7200 RPM
Monitor	19 inch (or larger) color Trinitron
Graphics	AGP card, 24-bit or 32-bit at 1024x1280 resolution
Peripherals	Floppy drive, CD-ROM
Operating system	Windows 2000, service pack 2
SCANNING SOFTWARE	
Calibration	Geometric XY stage, geometric sensor, radiometric sensor
Interior orientation	Interactive, semi-automated, fully automated
Scanning formats	VITec, raster TIFF, tiled TIFF, tiled TIFF JPEG, plain raster, Sun raster, NITF JPEG

TYPICAL SCANNING TIMES

Estimates* at 12.5 µm resolution	
Black and white aerial photograph	2 minutes
Color aerial photograph	5 minutes
Film advance one frame and automated interior orientation	30 seconds
Estimates* at 20 µm resolution	
Black and white aerial photograph	1.5 minutes
Color aerial photograph	3.5 minutes
Film advance one frame and automated interior orientation	30 seconds

** All scan times include on-the-fly rescaling, sharpening, user specified file format, re-orientation (flip, rotate), overview, and histogram generation, based on a PC with dual Pentium 4 processors.*

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Information subject to change without notice.

Part No. DSW600PD

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