NASA/TM-2003-212434

PIV Measurements in the 14 × 22 Low Speed Tunnel: Recommendations for Future Testing

Ralph D. Watson, Luther N. Jenkins, Chungsheng Yao, Catherine B. McGinley,
Keith B. Paschal, and Dan H. Neuhart
Langley Research Center, Hampton, Virginia

August 2003

The NASA STI Program Office . . . in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA counterpart of peer-reviewed formal professional papers, but having less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or co-sponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and missions, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results ... even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at ***http://www.sti.nasa.gov***

- E-mail your question via the Internet to help@sti.nasa.gov

- Fax your question to the NASA STI Help Desk at (301) 621-0134

- Phone the NASA STI Help Desk at (301) 621-0390

- Write to:
  NASA STI Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA/TM-2003-212434

PIV Measurements in the 14 × 22 Low Speed Tunnel: Recommendations for Future Testing

Ralph D. Watson, Luther N. Jenkins, Chungsheng Yao, Catherine B. McGinley,
Keith B. Paschal, and Dan H. Neuhart
Langley Research Center, Hampton, Virginia

National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

August 2003

Available from:

NASA Center for AeroSpace Information (CASI)
7121 Standard Drive
Hanover, MD 21076-1320
(301) 621-0390

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, VA 22161-2171
(703) 605-6000

PIV Measurements In the 14 X 22 Low Speed Tunnel: Recommendations For Future Testing

by Ralph D. Watson, Luther N. Jenkins, Chungsheng Yao, Catherine B. McGinley,
Keith B. Paschal, and Dan H. Neuhart

ABSTRACT

During the period from February 4 to March 21, 2003 stereo digital particle imaging velocimetry measurements were made on a generic high lift model, the Trap Wing, as part of the High Lift Flow Physics Experiment. These measurements were the first PIV measurements made in the NASA, Langley Research Center 14 x 22 Foot Low Speed Tunnel, and several problems were encountered and solved in the acquisition of the data. It is the purpose of this paper to document the solutions to these problems and to make recommendations for further improvements to the tunnel/setup in order to facilitate future measurements of this type.

CONTENTS

1. INTRODUCTION

During the period from February 4 to March 21, 2003 stereo digital particle imaging velocimetry measurements were made on a generic high lift model, the Trap Wing, as part of the High Lift Flow Physics Experiment. These measurements were the first PIV measurements made in the NASA, Langley Research Center 14 x 22 Foot Low Speed Tunnel, and several problems were encountered and solved in the acquisition of the data. It is the purpose of this paper to document the solutions to these problems and to make recommendations for further improvements to the tunnel/setup in order to facilitate future measurements of this type.

The model was tested at a Mach number of 0.2. The flap was set at 30 degrees and slat at 25 degrees. The nominal angle of attack range was from 4 to 28 degrees, although other angles outside this range were taken occasionally. A photograph of the model is shown in Figure 1.

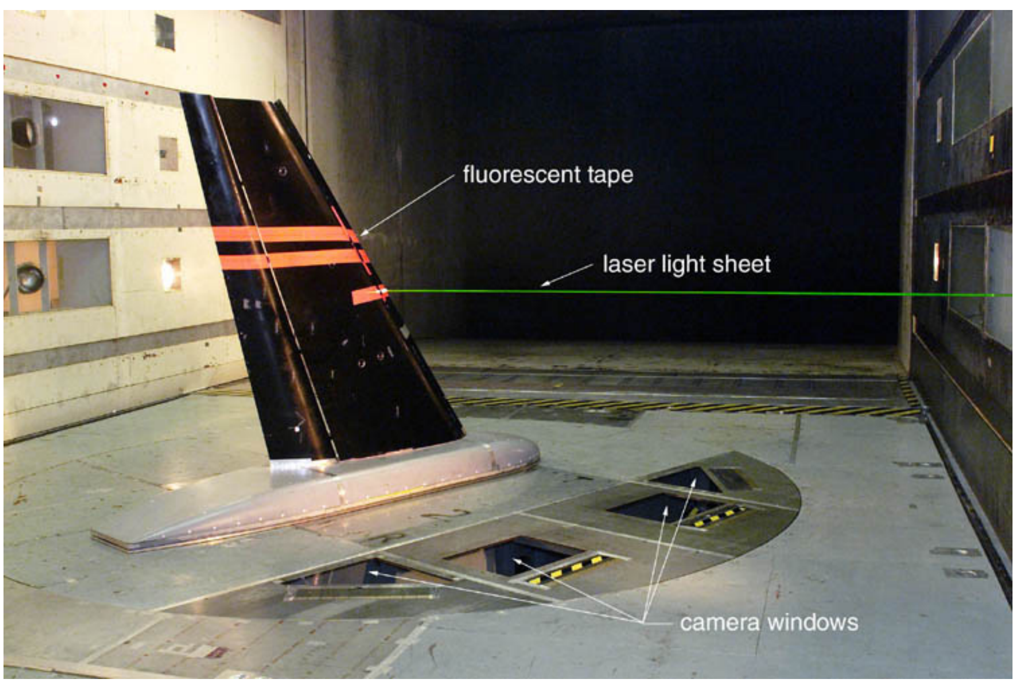

Figure 1. Trap Wing Model in 14 x 22 Low Speed Tunnel.

The remaining sections of this report describe the problems encountered during the test, the solutions to these problems, and the recommendations of the researchers for future tests in this tunnel.

2. MODEL IMAGING

For the trap wing, a semi-span 3-element wing mounted in the forward bay of the test section, measurements of the 3-dimensional vector field at several locations on the model at different angles of attack were required. Previous measurements on this model had shown regions of hysteresis in the lift and drag coefficients of the wing, and it was known from other tests that the flowfield was highly unsteady at the tip of the wing. For these and other reasons it was decided to survey the model at positions near the midpoint of the wing as close to rows of orifices as could be achieved and avoiding angles of attack where hysteresis effects would be present (-1.5 to +1 deg and 28 to 34 deg). Even at these locations the flowfield was highly 3-dimensional, and a challenging test for stereo PIV measurements.

In order to image the flowfield at different chordwise stations, a horizontal laser light sheet was required to impinge on the surface at various chordwise and spanwise locations from the leading edge of the slat to the trailing edge of the flap. See Figure 2 for a schematic of the setup.

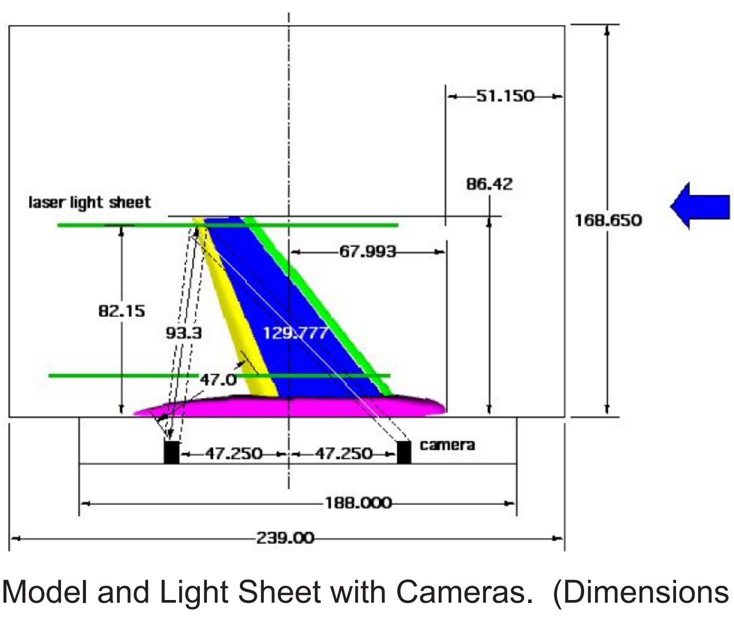

Figure 2. Model and Light Sheet with Cameras. (Dimensions in inches)

3. TUNNEL OPTICAL ACCESS

The Langley 14 x 22 Tunnel has very good optical access on both sidewalls and the tunnel ceiling. Unfortunately the glass has been pitted from long use and is difficult to remove and replace. Figure 5 is a sketch of the north wall of the tunnel test section showing the window arrangement. The south wall and ceiling window arrangement are slightly different from the north wall arrangement; however, all walls have a series of long windows for optical access.

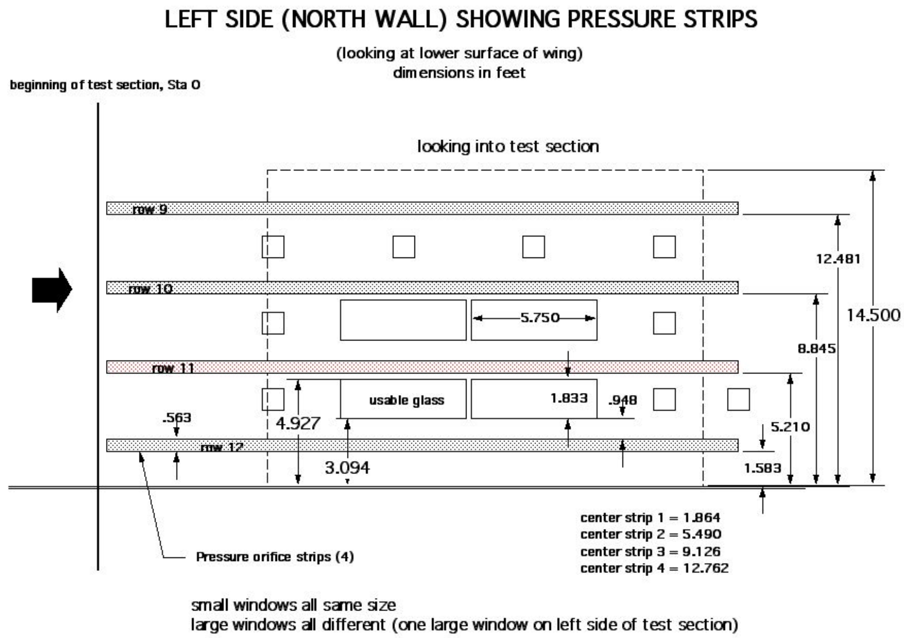

Figure 3. Tunnel Window Arrangement on North Wall.

The obvious choice for mounting the laser and optics to generate a horizontal light sheet impinging on the upper (suction) surface of the model was behind the south wall of the tunnel. The laser was mounted on an optical table, which was part of the tunnel equipment. Research personnel designed and mounted the optics. Minor problems were encountered when the light sheet went through the tunnel windows due to pits in the surface of the glass. Some adjustment of light position was made to find good sections of the glass. This mounting of the laser and optics proved to be successful, and no significant vibration problems were encountered at the tunnel conditions for this particular test. The floor behind the south wall, on which the laser-optics table was mounted, is fixed and the model itself is mounted on a cart that is locked in place to the floor. Some relative motion was anticipated between the cart and floor; however, this did not prove to be a problem. The walls can be lifted away from the floor so that the tunnel can be run in an open jet configuration, and problems were encountered in mounting optics to the tunnel sidewalls. A rail on which slider blocks were mounted was attached to the south wall in order to move the light sheet to any desired vertical location. Unfortunately, the walls vibrated independently of the model and camera mounting to the extent that data could not be taken accurately. Therefore, this arrangement was abandoned.

For future PIV tests in this tunnel, it is suggested that the window mounting be modified so that sections of low-iron glass can be easily installed and removed in case of damage to the window surface. These sections would probably be located at the midpoint of the model cart for maximum versatility. There will be gaps in the optical access due to the presence of the wall pressure orifice mounting areas; however, this should not be a significant problem for data acquisition. For imaging the wake, additional window modifications should be made at the downstream end of the cart. Since the light sheet is vertical for this arrangement, the whole sheet can be tilted up or down for full coverage of the wake.

4. LASER-OPTICS SETUP

The resolution of the cameras used in this test was1280 by 1024 pixels, giving a maximum image area at the model of approximately 8 inches by 8 inches using lenses with 50 mm focal lengths. Resolution was approximately 0.2 inches (5 mm) with this arrangement, based on an interrogation size of 32 pixels. Lenses with 105 mm focal lengths, giving an image size of 6 by 6 inches were used near the leading edge of the model to improve the resolution.

The laser and optics were set up outside the south wall of the test section. A dual-beam Nd-Yag laser, 200 mJ, was mounted to a plate which also contained a reflecting mirror, two cylindrical lenses, and a focusing lens. The plate, which was mounted on an optics table as shown in Figures 4 and 5, could be rotated and translated behind the south wall. Although this arrangement worked well, it was tedious to move and align. A motorized arrangement would be useful for future setups.

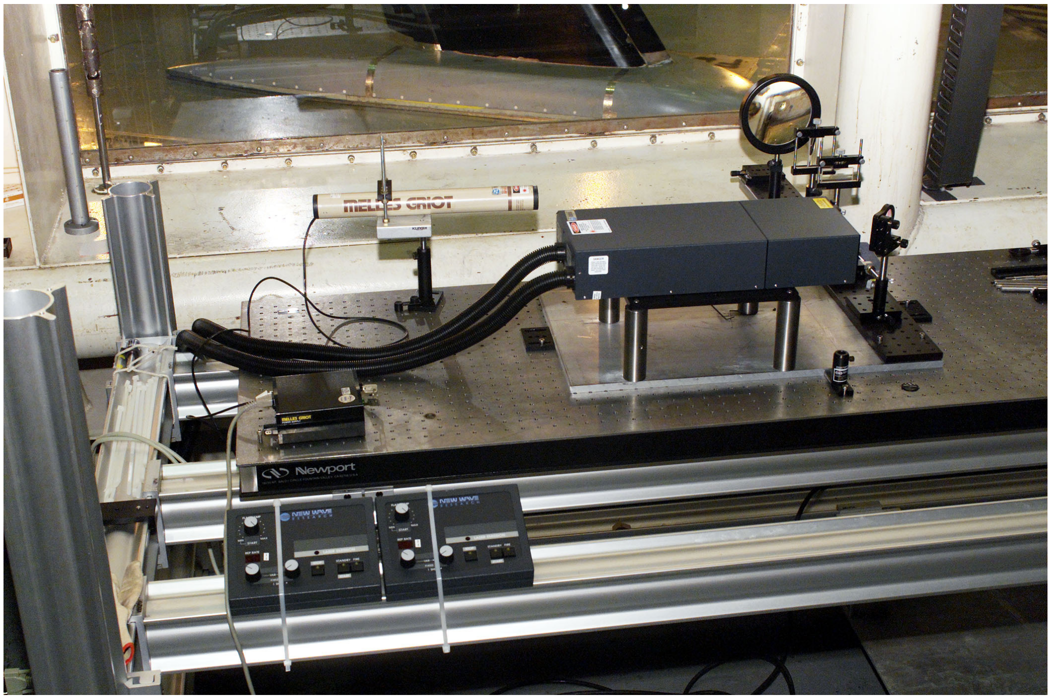

Figure 4. Laser-Optics Setup.

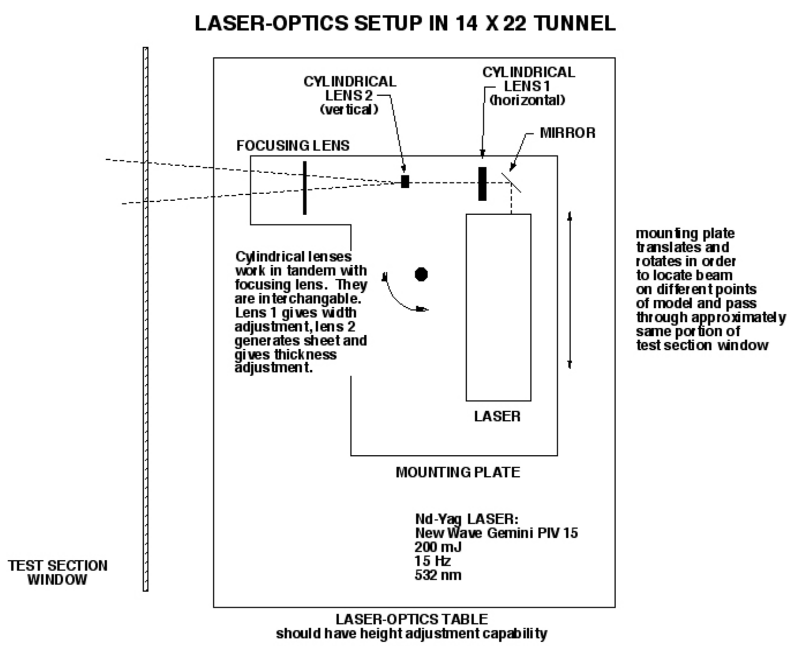

Figure 5. Laser-Optics Mounting Arrangement.

The cylindrical lenses were used to create a light sheet from the laser beam and to control the thickness of the sheet. The sheet thickness is an important parameter.   If too thin, particles will traverse the sheet too quickly and data will not be obtained; if too thick, the light intensity will not be great enough to illuminate the seeding particles. It was found that a thickness of between 3 and 4 mm worked well for the conditions of this test.

5. CAMERA MOUNTING

In order to image the flow within the horizontal light sheet in the vicinity of the model, the cameras needed to be mounted out of the airstream either above or below the light sheet and offset, preferably equidistant from the center of the imaging area. The choices in this case were through the tunnel floor or through the ceiling windows. Since the model would be moved to different angles of attack on tunnel Cart No. 2 using a turntable arrangement, the best choice was to mount the cameras within the turntable. As the model moved to different angles of attack the cameras would move with the model and the calibrated target area would not change. This necessitated replacing aluminum cart plates with new plates containing windows – see Figure 6. The windows were of good quality, low-iron glass, commercially available as “Starfire.”

When camera views were changed, a laptop computer was temporarily connected to the cameras to adjust the focus and Schienpflug angles. Adjustments were made to the cameras by means of access hatches in the floor plates adjacent to the windows.

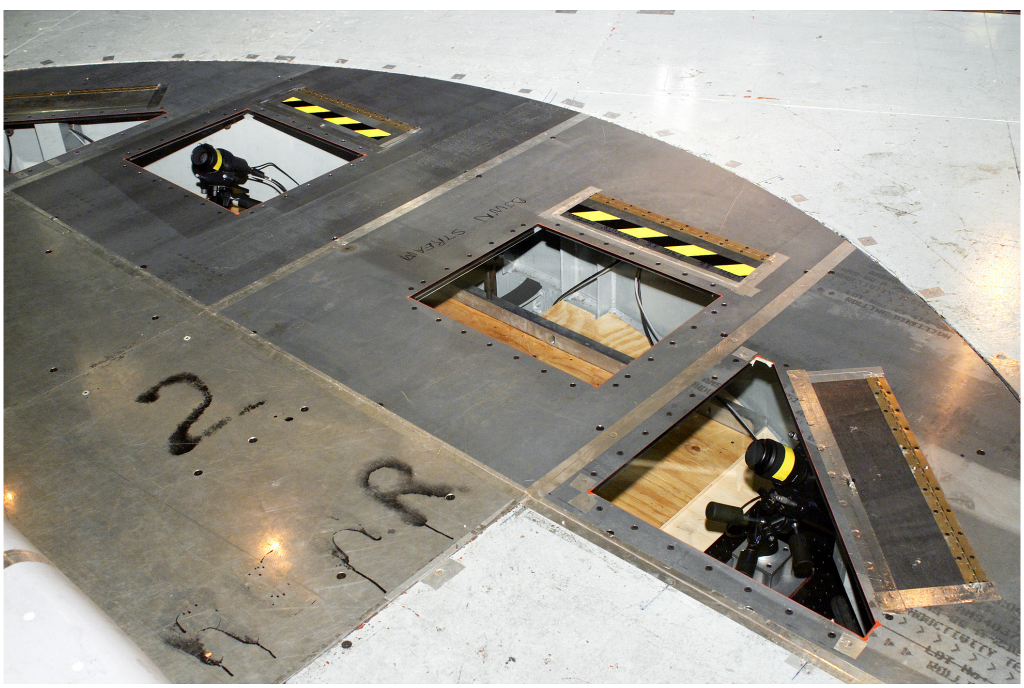

Figure 6. Cameras Mounted Under Floor of Turntable on Cart No. 2.

6. DATA ACQUISITION AND STORAGE

There are several data acquisition/reduction/display packages available for acquiring PIV data; however, the only one known to the authors that is capable of data acquisition with cameras in a stereo setup mode such as used for this test, is that sold by Integrated Design Tools of Tallahassee, Florida. In addition to buying the software and hardware from this company, the services of company personnel were obtained under contract in order to facilitate the solution of software and hardware problems during the test. This proved to be of great value since, in several instances, the software was found to contain bugs and problems were fixed quickly by having the software engineer available. This test pushed the limits of the software, since it consisted of camera setups that are usually not encountered in smaller tunnels or laboratory environments. It is recommended that the software and hardware purchase be very carefully considered, and that additional support be provided under contract when new PIV setups are considered. The cost of testing in large facilities such as 14 x 22, makes the additional cost of services provided under contract to be very worthwhile.

The data acquisition computer and camera control boxes were located underneath Model Cart No. 2. This was necessary because the cameras were firewire-controlled (IEEE-1394), and were limited to cable lengths of 20 ft. Control of data acquisition and reduction was performed in the control room during the test. The keyboard, mouse, and monitor were located in the control room and 100-foot-long cables were run underneath the model cart to connect these devices to the computer.

In order to provide good mean values of the flow vectors and to provide limited statistical quantities, 500 stereo images were acquired when possible at each survey position and angle of attack. For this test, 9 positions were imaged and 7 angles from 4 to 28 degrees were taken. The resulting database, which includes many test setups and calibrations in addition to the good data runs, contains approximately 200 gigabytes of data. It is imperative that adequate storage and archive capability be provided. Archive capability has been provided for this data using AIT tape storage, with each tape holding 50 gigabytes of data.

7. SEEDING THE FLOW

The two obvious parameters required for adequate PIV seeding are the density of the particles and the size of particles. Two different types of fog generators using different fogging liquids, as well as various placements of the fog generators upstream of the model were tried. A water-based fluid, which has proved adequate for PIV seeding in smaller tunnels was first tried, however the largest generator available did not produce enough fog to adequately seed the flow. The particle images, however, looked good.

Next, an oil-based fluid was tried using a different type of generator. Adequate smoke to fill the tunnel was produced; however, it was found that the size of the particles was too small to produce consistent PIV measurements. For this reason, the oil-based generator was not used.

Finally three generators using water-based fluid were used, providing adequate particle density in most cases. The particle size was approximately one micron in diameter - of good size for PIV measurements. It was found that during warm weather, as the tunnel heated to approximately 78 deg F, the particle density decreased to the point where data was obtainable only for short times (usually 80 stereo images could be acquired). Below this temperature it was possible to obtain data for as long as desired.

Placement of the seeders was found to be important. Seeders were initially placed in the settling chamber on the floor slightly upstream of the screens. Since boundary layer suction was used for this test, seeding was not adequate when the seeders were placed on the floor. They were placed on a stand elevated about 4 feet off the floor, shown in Figure 7. This arrangement provided adequate seeding, being most dense near the base of the model.

In an attempt to provide more uniform seeding, the fog generators were moved to upstream of the first turning vanes downstream of the fan drive. This arrangement provided more uniform seeding, however, the size of the particles was too small. Therefore, the fog generators were moved back to the original position in the settling chamber elevated about 4 feet off the floor.

Since the model was mounted on the floor of the tunnel, the Boundary Layer Removal System (BLRS) was used to reduce the boundary layer thickness upstream of the model. During its operation, it was noted that a significant portion of the seed material was being removed from the tunnel. This had a significant effect on the seed density if the BLRS was turned on before the seeders. It was found that turning the seeders on and running the tunnel at a low Mach Number for some time prior to turning on the BLRS permitted enough seed particles to build up in the tunnel, making their subsequent removal almost undetectable.

The fog generators were started and stopped manually, which entailed going into the settling chamber to turn them off and on. A remote-control switch capable of controlling at least three fog generators would be a worthwhile addition to the tunnel if more PIV measurements were to be made.

Figure 7. Fog Generators in Settling Chamber.

8. CALIBRATION TECHNIQUE

The accuracy of the data obtained using PIV is directly related to the quality of the calibration. A target is imaged by two cameras in the stereo mode and must be accurately translated to several positions in front of and behind the image plane to provide a series of stereo images. These images are processed by the software to establish the conversion between the camera pixels and actual distances in the image plane, as well as to correlate points within the two camera views. A known position on the target, or in the field of view, is used to establish a reference point for the images. When the calibration has been made, particles within the field of view are accurately located in relation to the reference point.

It is absolutely necessary that a rigid stand be built capable of holding and accurately moving the target to perform the calibration. The stand used for this test is shown in Figure 8. Klinger rails were used to construct the stand and a micrometer adjustment mechanism used to accurately move the target in the vertical direction. A range of +- 2 mm was used about the zero point. The setup and disassembly of the calibration stand were very tedious. Each configuration to be tested will require a calibration stand capable of providing the necessary rigidity and access to the desired survey location without casting shadows or blocking the field of view. In addition, a sufficient light source will be necessary to illuminate the calibration points and speckle pattern on the calibration target. It was found that this could be accomplished using 300 watt halogen lights typically used for workshop applications.

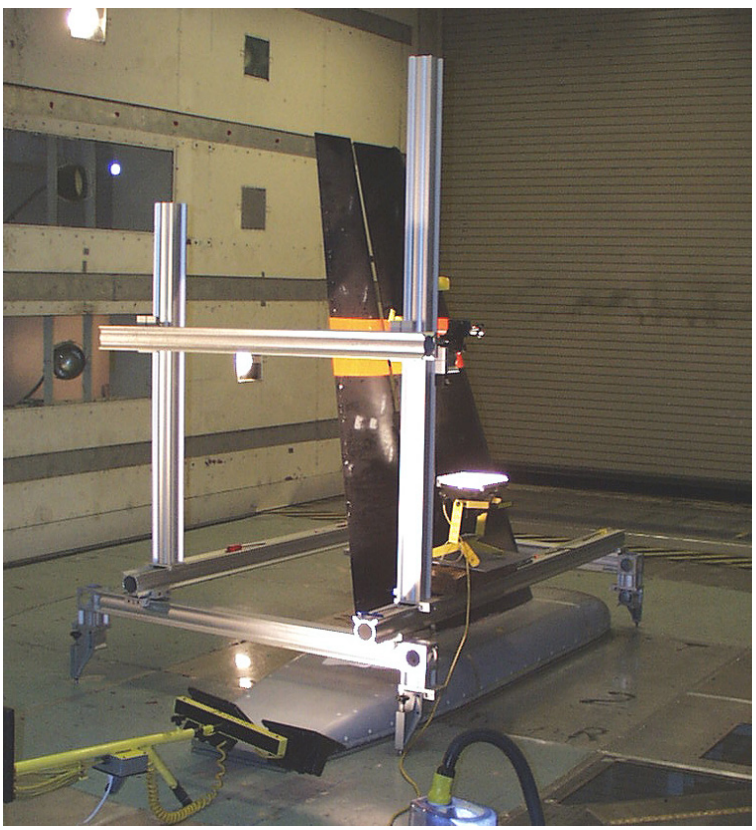

Figure 8. Calibration Rig.

9. GENERAL PROCEDURE FOR STEREO PIV DATA ACQUISITION

The model surface is treated with fluorescent paper/paint before PIV operation. The purpose of the fluorescent treatment is to reduce the surface glare from the laser recorded on the PIV images. The following steps are a general procedure for a SPIV test:

1. Position the PIV laser light sheet at the desired measurement location in the test section.
2. Adjust light sheet width and thickness to desired settings and orientation.
3. Install PIV calibration target aligned with the light sheet (front surface of calibration grid centered on the light sheet).
4. Position stereo cameras, through translation, tilting and panning, to capture the desired field of view and to maximize image overlapping between the two stereo cameras.
5. Focus stereo cameras. General focusing uses the calibration target. Fine focusing is done through sharpening the images while viewing micron-sized particles locally seeded at the measurement volume. Focus particle images from corner to corner within the field of view to meet the Scheinpflug condition.
6. Re-install calibration target for PIV calibration. Measure target geometry and position, in reference to either wind tunnel or model coordinates, to define PIV interrogation grid coordinates.
7. Calibrate PIV cameras through standard Stereo PIV calibration procedure provided by the PIV software. Calibration maps the camera imaging plane to the calibration grids. Confirm calibration accuracy with known target displacements. Camera recalibration is not required as long as the relative positions between the two cameras and the laser light sheet are unchanged.
8. Proceed with wind tunnel test. Adjust exposure brightness and contrast. Adjust laser pulse separation. Sample PIV images to ensure satisfactory seeding density, particle image exposure, and PIV signals (image correlation), etc., improving PIV data validation.
9. Acquire and save stereo PIV images..

10. WAKE SURVEYS

In order to determine the feasibility of surveying the wake downstream of models, the camera and laser-optics setups and calibration rig were modified. The light sheet was changed from horizontal to vertical and the cameras were moved from the cart turntable beneath the model to behind the north wall on either side of the light sheet. Seeding problems were almost nonexistent with this arrangement since particles were imaged in the forward-scatter mode and the signal was very strong. Previously, the imaging was in the back-scatter mode. Figure 9 shows the frame arrangement for rigidly mounting both cameras. It was imperative that both cameras be mounted so that there was no relative vibration between the cameras. I.e., the frame should be as rigid as possible. Figure 10 shows the new calibration target rig that was used in this configuration. For wake surveys the target was mounted in a vertical plane, whereas for model flowfield imaging, the target was horizontal. Some data was taken using this arrangement, although time did not permit a complete survey of the wake.

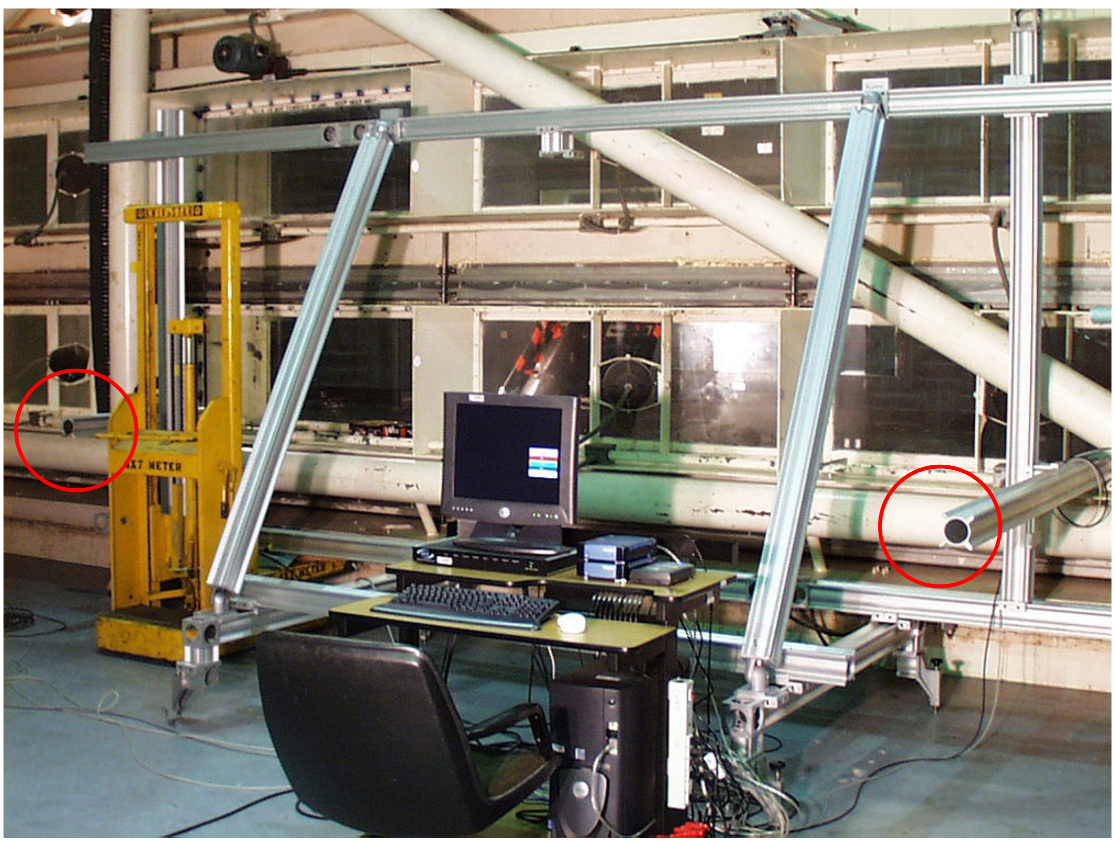

Figure 9. Camera Frame for Wake Measurements.

Red circles indicate posts on which cameras were mounted.

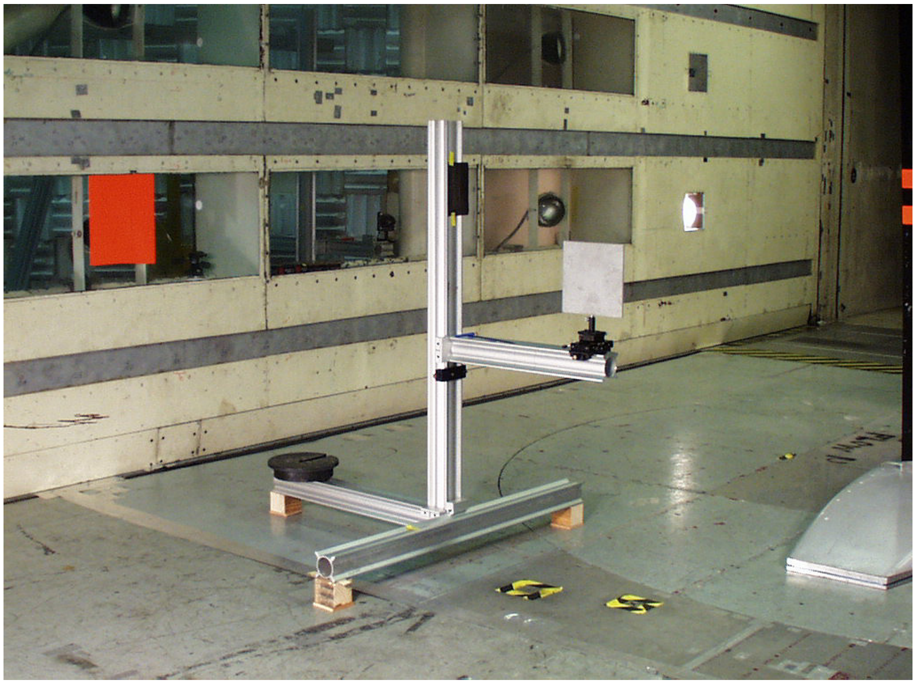

Figure 10. Wake Calibration Rig.

It is recommended that for future PIV wake surveys, the imaged area be a large as possible in order to decrease the setup time in imaging the complete wake. Special, smaller focal length lenses and larger targets may be required for this. Resolution is not as important in the wake as it is for imaging the flowfield over the model.

11. SAFETY ISSUES

There were no major safety problems with this test. Interlocks were already in place due to previous tests using the laser-doppler technique for point measurements. The obvious requirement was to provide an adequate supply of laser goggles to personnel.

The personnel running Test 513 were, in several cases, PIV users and very knowledgeable concerning the safe operation of the New Wave laser. Laser safety cannot be overemphasized.

A point that should be mentioned is that after running for several weeks, the tunnel floor became slippery at some locations. Consideration should be given to periodically inspecting surfaces in the test section and cleaning as required while seeding of the tunnel is taking place.

12. TUNNEL LIGHTING

In some cases, the tunnel lights, both behind the north and south walls and the ceiling, caused problems with PIV imaging.

Filters were installed in the cameras to reject all wavelengths other than the 532 nm laser light. Since white light contains all wavelengths, some effects were seen when the light from the tunnel walls scattered off different parts of the model (e.g., brackets and regions of the slat cove). This problem could possibly be more pronounced for unpainted models with polished surfaces. The proper tunnel lighting can be determined by systematically turning off the tunnel lights while viewing the images in real time.

It may be possible in the future to use polarizing filters over lights to reduce glare when PIV measurements are being made.

13. SUMMARY OF RECOMMENDATIONS

General

1. Do not mount optical components on the sidewalls of the test section.
2. Modify the window mounts so that low-iron glass can be easily installed and removed.
3. Carefully choose hardware and software to facilitate data acquisition and reduction. Not all software can account for the camera angles used to image the model in this test.
4. Provide adequate storage and archive capability for the large data files generated by PIV.
5. Insure that the calibration rig is easy to set up and dismantle, and is very rigid.
6. Add remote control capability for at least 3 fog generators in the settling chamber.
7. Use the largest image area in the wake that can be reasonably obtained.
8. Oil accumulation can be expected during PIV tests. Inspect surfaces for oil buildup and clean as needed.
9. Consider the use of polarizing filters or other treatment of test section lights to reduce glare in PIV cameras.

Laser-Optics Setup

1. The PIV laser and light sheet forming optics (including mirrors, cylindrical and spherical lenses) should be mounted on either an optical bench or a breadboard that can be translated as one integral unit.
2. The PIV laser-optics platform should be mounted on a long rail or a translation slide with either a manual or motorized stage. The rail or slide will be installed parallel to the test section on the outside of the test section. The length of the rail should be long enough to cover all interested test stations in the streamwise direction. The light sheet, either vertical or horizontal, will be projected into the test section through windows on the sidewalls.
3. The position of the light sheet, i.e., the x-location of the vertical light sheet or the y-location of the horizontal light sheet, should be precisely and conveniently measured in reference to the test model or wind tunnel coordinates. The light sheet may use the side window as a reference to check for incidence angle, i.e., 90 degree perpendicular to the sidewall, into the test section. Alternatively, a reference surface may be set up inside the test section to check for laser sheet position and orientation, such as a mirror perpendicular to the floor at a known position. The coordinates of the PIV interrogation grid are determined from the calibration target that is referenced to a known point on the model or in the tunnel.
4. The light sheet forming optics might include a periscope extension to guide the laser sheet to variable heights. The tunnel should provide adequate optical access in both streamwise and vertical directions.
5. The calibration grid target should be mounted on a precision adjustable platform that can be translated, tilted, and rotated to conveniently align the target with the laser light sheet and to whatever reference surface is used, either floor or side wall, etc. A small alignment laser can be used to align the target. The calibration platform should be mounted on a rigid system with easy installation and positioning because calibration is a very time consuming process in setting up PIV. The calibration target should be uniformly illuminated with a bright light source projected onto the surface at an angle to enhance the contrast of the

speckle patterns to be recorded. (The IDT calibration is actually done by measuring the movement of the speckle pattern.)

6. The optimal stereo PIV orientation requires laser light projected into the test section from one side of the wind tunnel and stereo cameras mounted on the opposite side of the wind tunnel. In this case, particle scattering will be in the strong forward-scattering mode. Wake flow measurement is a typical setup that is done in this manner.
7. For efficiency in the imaging setup, stereo cameras should be mounted on a rigid platform with precision adjustable stages for translation, tilting, and panning. The camera focusing mechanism should be motorized with a remote control to fine tune the image focal point and Scheinpflug adjustment.
8. To save wind tunnel testing time, double stereo camera systems may be considered, i.e., two pairs (four cameras) of stereo imaging systems which may share the same laser light sheet but record flow fields at different locations within the light sheet.

APPENDIX
EQUIPMENT USED IN TEST 513

a. Dual-beam Nd-Yag laser, power 200 mJ. New Wave Gemini PIV 15.
b. Two cameras, IDT 1400 DE. Resolution 1280 by 1024. Firewire connections. IDT timing control interface box communicating with National Instruments DAC card installed in computer.
c. Camera lenses for imaging desired PIV region, 50 mm and 105 mm Nikon lenses used for this test. Others, possibly zoom, would have been useful.
d. Lenses, mirrors, and associated optics for creating laser light sheet.
e. Dell Dimension PC with dual processors. 200 GB external disk for data storage.
f. IDTsoftware, proVISION II for data acquisition, analysis, and reduction. Requires Tecplot capability on computer for data reduction.
g. Sony VAIO laptop computer with IDT software for camera imaging and focusing in test section.

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
01- 08 - 2003

2. REPORT TYPE
Technical Memorandum

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
PIV Measurements in the 14 x 22 Low Speed Tunnel: Recommendations for Future Testing

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Ralph D. Watson, Luther N. Jenkins, Chungsheng Yao, Catherine B. McGinley, Keith B. Paschal, and Dan H. Neuhart

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
23-762-20-11

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Langley Research Center
Hampton, VA 23681-2199

8. PERFORMING ORGANIZATION REPORT NUMBER
L-18304

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSOR/MONITOR'S ACRONYM(S)
NASA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
TM-2003-212434

12. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited
Subject Category 09
Availability: NASA CASI (301) 621-0390 Distribution: Nonstandard

13. SUPPLEMENTARY NOTES
An electronic version can be found at http://techreports.larc.nasa.gov/ltrs/ or http://ntrs.nasa.gov

14. ABSTRACT
During the period from February 4 to March 21, 2003 stereo digital particle imaging velocimetry measurements were made on a generic high lift model, the Trap Wing, as part of the High Lift Flow Physics Experiment. These measurements were the first PIV measurements made in the NASA, Langley Research Center 14 x 22 Foot Low Speed Tunnel, and several problems were encountered and solved in the acquisition of the data. It is the purpose of this paper to document the solutions to these problems and to make recommendations for further improvements to the tunnel/setup in order to facilitate future measurements of this type.

15. SUBJECT TERMS
Aeronautics

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			STI Help Desk (email: help@sti.nasa.gov)
					19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	23	(301) 621-0390

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18