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Hawkeye

Technical Manual

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Hawkeye System Specifications

- The Hawkeye combines three systems to size and image particles: a forward scattering module for sizing of particles from 1 to 50 μ m, a CCD camera and two imaging arrays that can image particles in three different views and two different resolutions.
- The CCD produces high-resolution (\approx 2.3 micron pixel size) digital images at nearly 400 fps. Each frame can potentially image more than 25 particles per frame.
 - 1024 x 1280 image area
 - \approx 2.3 μ m/pixel size resolution
 - 8 bit grey scale (256 levels)
- Two independent 128 pixel photodiode arrays with optics configured for 10 and 50 micron pixel resolution, resulting in a maximum field(s) of view of 1.28 mm and 6.4 mm respectively.
- The electronics can operate at true airspeeds up to 200 m/s.
- Particles up to 1.28 mm are completely imaged, and even larger particles can be sized in the direction of flight.
- The Sensor Head is hermetically sealed and operates up to 70,000 feet altitude.
- De-ice heaters are temperature controlled and the user can change set points in flight.
- The Hawkeye Probe is designed for unmanned use, with AI parameters to optimize performance without supervision.

Hawkeye Measurement Channel	Size Range	Resolution
CPI	2.3 μ m – 2.5 mm	\approx 2.3 μ m
2D-S 10 μm	10 μ m – 1.28 mm	10 μ m
2D-S 50 μm	50 μ m – 6.4 mm	50 μ m
FCDP	1 μ m – 50 μ m	3 μ m

Hawkeye Power Requirements

Input	Voltage	Frequency	Power	Usage
Computer (in cabin)	115 – 240 VAC	50 – 60 Hz	400 W	Data System Power
Probe Electronics	28 VDC	DC	210 W	Sensor Electronics
Probe AC1 and AC2	115 VAC	60 – 400 Hz	1600 W	Pylon Heaters

Hawkeye Probe Electrical Interface Requirements

Power Wiring (11 wires):

- 7 conductors: (3-AC and 3-return 1-frame) 16 gauge (9 amps each max,)
- conductors: (+28v, Gnd) 16 gauge (6 amps each)
- conductors: (+28v, Gnd) 16 gauge (2 amps each)

Signal Wiring (20 wires):

- 12 conductors: (5 twisted pair & 2 Gnd for 422 and diff. camera signaling)
- 22-28 gauge (aircraft grade cat 6 works well)
- 4 conductors: (twisted pair Ethernet)
- 22-28 gauge (aircraft grade cat 6 works well)
- 4 conductors: (twisted pair Ethernet)
- 22-28 gauge (aircraft grade cat 6 works well)

Camera Data (4 optical fibers):

- 4 fiber optic cables (62.5/125 multimode fiber – FAR25 aircraft approved)
- Fiber termination at cabin computer: two LC duplex connectors (Glenair 6828129-1)
- Fiber termination at probe: one MIL-DTL-38999 from glenair (connector 180-091XW06-13-4SN, with 189HS016NF1305-4 backshell)

Hawkeye Weight and Size

System Component	Weight	Size
Probe	65 lbs (30 kg)	32" x 16" x 6.5" (81 cm x 40.6 cm x 16.5 cm)
Data System	45 lbs (23 kg)	19" x 20" x 7" (48 cm x 51 cm x 18 cm)

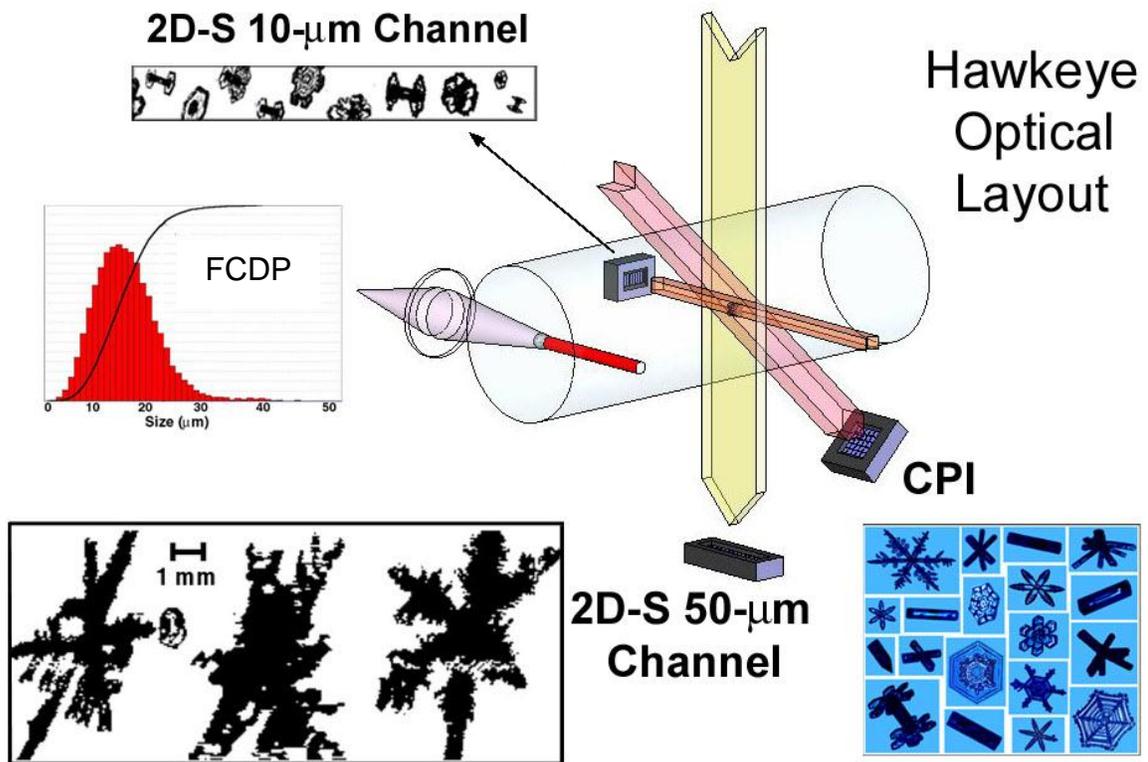
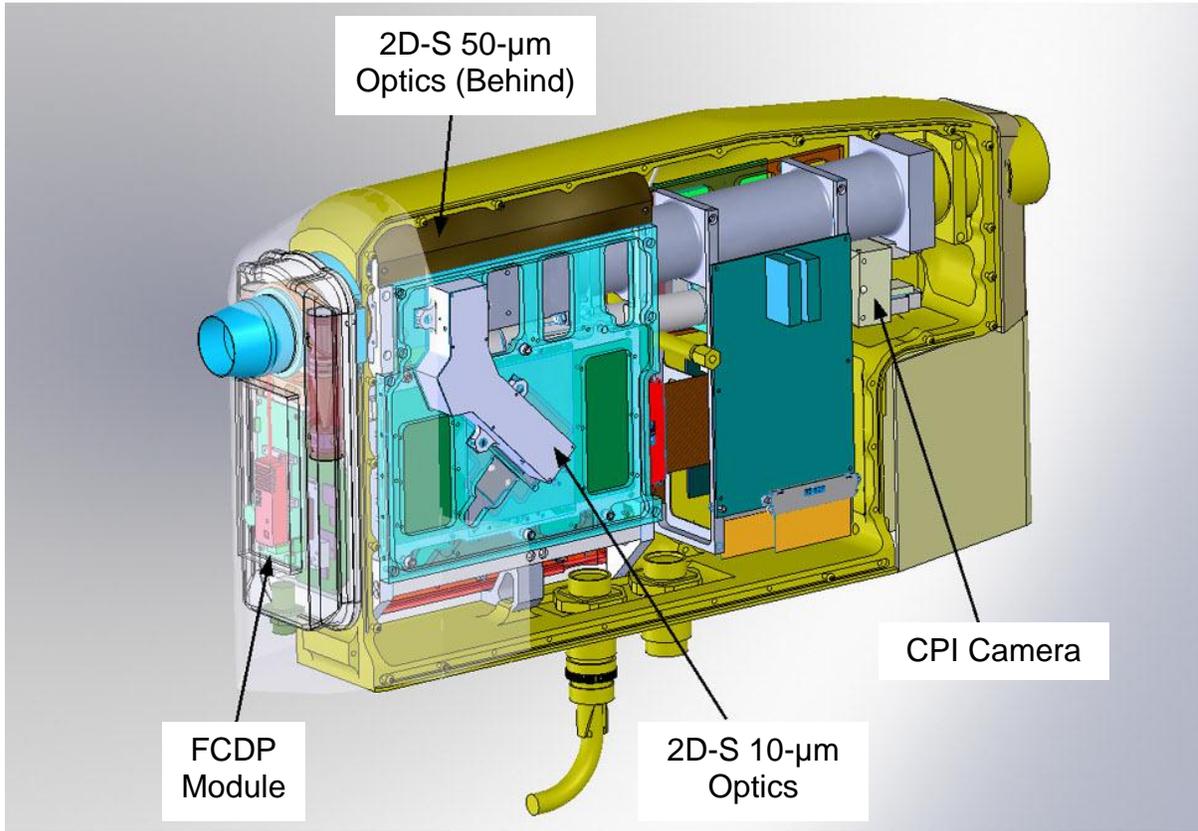


TABLE OF CONTENTS

Hawkeye System Specifications	<i>i</i>
1 Hawkeye Overview	1
1.1 Hawkeye 3V-CPI	1
1.1.1 <i>Main Parts of the 3V-CPI</i>	1
1.1.2 <i>Hawkeye 3V-CPI Functional Overview</i>	2
1.2 Hawkeye FCDP	6
1.2.1 <i>Main Components of the FCDP</i>	6
1.2.2 <i>Hawkeye FCDP Functional Overview</i>	7
2 Getting Started	9
2.1 Unpacking the Hawkeye System	9
2.2 Connecting the Hawkeye Sensor Head to the Data Acquisition System	11
2.2.1 <i>Connection Procedure for Operating the Hawkeye in the Laboratory</i>	11
2.2.2 <i>Connection Procedure for Installing the Hawkeye on an Airplane</i>	12
2.3 Hawkeye Startup Procedure	21
2.4 Hawkeye Shutdown Procedure	27
2.5 Disconnecting the Hawkeye Cables	28
2.6 Packing the Hawkeye	29
3 Maintenance Procedures	30
3.1 Purging and Fairing Removal	30
3.1.1 <i>Purging the Pylon through the Rear Fairing</i>	30
3.1.2 <i>Purging the FCDP through the Front Fairing</i>	33
3.2 Cleaning Hawkeye Optical Windows	39
3.3 Pylon Cover Removal and Replacement	45
3.3.1 <i>Pylon Cover Removal</i>	45
3.3.2 <i>Pylon Cover Replacement</i>	49
3.4 Atomizer Setup for Laboratory Testing	52
Appendix A: Attachment Footprint	55

1 Hawkeye Overview

The Hawkeye is an airborne atmospheric research instrument that combines the capabilities of the 3V-CPI with a forward scattering spectrometer module, the Hawkeye Fast Cloud Droplet Probe (FCDP). Additionally, the 3V-CPI is composed of two parts the Stereo Particle Imaging Probe (2D-S) and the Cloud Particle Imager (CPI). The 2D-S portion of the 3V-CPI is an airborne optical instrument that measures the size, shape and concentration of atmospheric particles with two cross-sectional laser arrays. The CPI is triggered by the 2D-S to capture high-resolution images of particles as they pass through the instrument. The FCDP also measures particle size and concentration, and operates separately from the 3V-CPI.

1.1 Hawkeye 3V-CPI

1.1.1 Main Components of the 3V-CPI

The 3V-CPI can be subdivided into two basic parts, shown in the block diagram, **Figure 1.1.1**. The first part, the Data Acquisition System, is housed inside a rack-mount computer case. This is usually mounted inside the aircraft cabin. The second part is the Sensor Head, or Pylon, which is located outside the aircraft on the fuselage or wing.

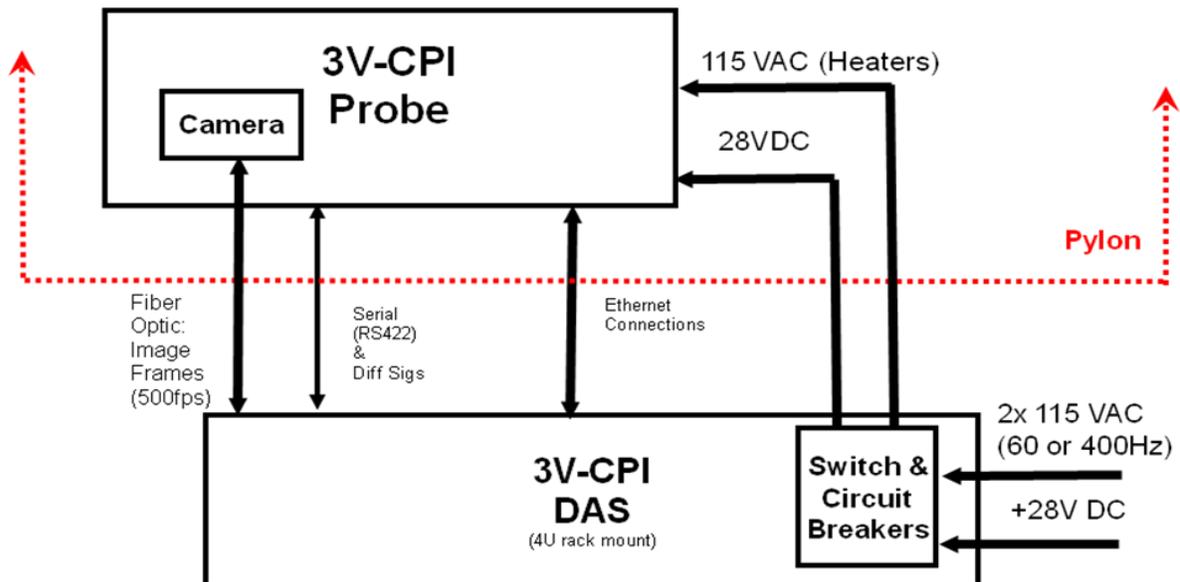


Figure 1.1.1. 3V-CPI Block Diagram.

1.1.2 3V-CPI Functional Overview

The 2D-S portion of the Hawkeye 3V-CPI has two optical imaging channels that are orthogonal to each other and normal to the flow of particles. Each channel uses a fiber coupled diode laser that produces a sheet of laser light. The vertical channel is roughly 1.28 x 50 mm in size, the horizontal 6.4 x 50 mm and both pass between the windows located on the inboard sides of the optical arms. Each sheet of light is directed onto a linear photodiode array of 128 elements with the magnification required to produce approximately 10-micron pixels in the sample volume of the vertical channel and 50-micron pixels for the horizontal channel. The array is sampled at a rate proportional to the velocity of the particle, such that image slices are taken at the pixel resolution.

Image slices are compressed and blocked into particle frames that are sent to a data acquisition system (DAS) for recording and display on the 2D-S Graphical User Interface (GUI). When the laser array detects that a particle is present in object plane of the imaging system, a high-power laser flashes. A CCD camera records the particle image(s) and the frame containing the particle(s) is sent to an image processing system that locates the particle(s) in the image and cuts out these regions of interest (ROI) for display and recording.

The CPI GUI is used to control the numerous parameters for the CCD camera. The imaging system utilizes a 1024 x 1280 pixel monochrome digital camera that has eight bits of resolution (256 levels) and has an effective pixel size of ≈ 2.3 microns. The camera can download up to 400 frames per second, allowing the instrument to rapidly image small cloud particles.

Instrument Behavior with No Particles Present

Figure 1.1.2 shows the primary electro-optical components in the 3V-CPI. The upper left diagram shows a 3-D rendering of the 3V-CPI sample volume. Two ribbon-shaped intersecting laser beams form the 2D-S laser array, one horizontal (90) and one vertical (45). Both lasers are functionally identical. The object plane for the imaging CCD camera is located on the trailing edge of the 2D-S beam intersection.

Upon instrument startup, the imaging system pulses the imaging laser and captures a full frame background CCD image in the absence of cloud particles. The background image is stored and used to process subsequent frames thought to contain a particle image. The background CCD image is shown on the right side of **Figure 1.1.2**.

Each channel of the 2D-S is directed at a photo-diode array, which consists of a 128-element, linear array of photo-diodes. Each diode produces a photo current that is proportional to the light incident on its active area. As a particle passes through the sample volume, a shadow passes over the array, thereby reducing the current. If there is no shadow, then no particle is detected and no firing of the imaging laser occurs. The imaging CCD camera is constantly downloading images, but during this period of no particles, the camera's light sensitive surface is never exposed and the images are discarded by the data acquisition system.

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Instrument Behavior with Particle(s) Present

As a particle passes through the sample volume, a shadow passes over the vertical and the horizontal arrays, reducing the current. The photo current is converted to a voltage with a two-stage trans-impedance amplifier. This voltage, the element voltage, is compared with a low-pass filtered, baseline restored version of itself to create a binary value from each diode. The binary value will be TRUE when the shadow exceeds fifty percent of the average element voltage. These binary values form the digital IMAGE vector that is sent to the control module.

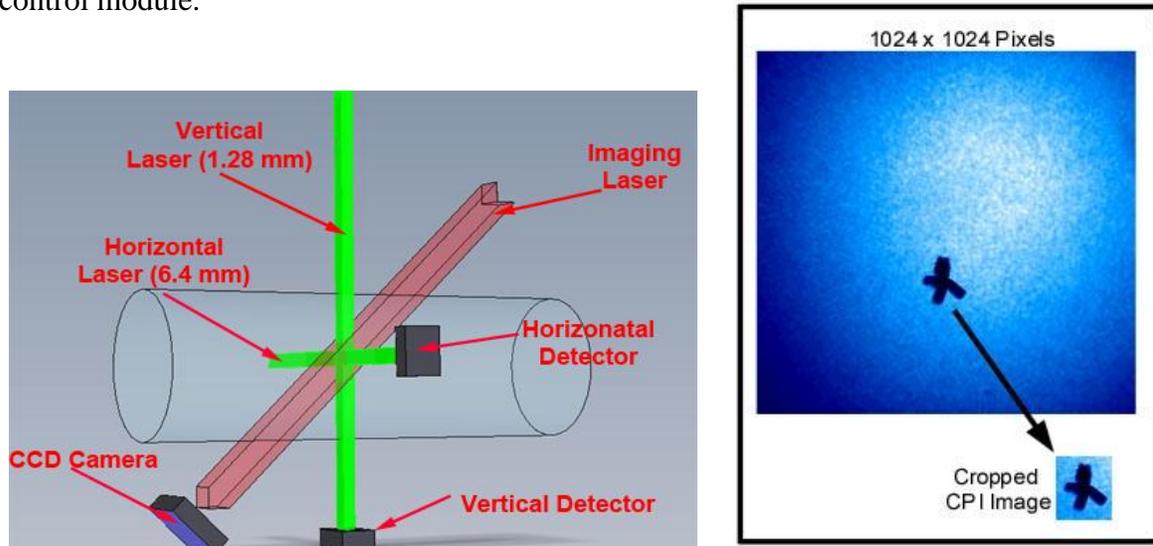


Figure 1.1.2. 3-D portrayal of optics and exposed image of the CCD camera when a particle is present.

If the particle sensed by the 2D-S arrays passes the triggering criteria set by the user in the CPI setting, then the probe proceeds to trigger the camera. To correctly capture the camera image, a logical state machine located in the sensor head steps through a six step cycle. This state machine orchestrates the imaging of the particle, the sending of data associated with that particle to the Data Acquisition Computer, and the resetting of the electronics in preparation for the next particle. The states of this state machine are as follows:

- State 0: Idle and wait for a particle. If a particle is sensed that passes the triggering criteria, go to State 1.
- State 1: Start a timer that measures the time during which the particle is in both of the 2D-S beams. This is called the Transit Timer. Wait for the Particle In Beam OK (PIB_OK) signal to go low. This signal goes high when both of the 2D-S pulses have been high for longer than a minimum duration. When PIB_OK goes low, jump to state 2.
- State 2: Fire the imaging laser. Notify the frame grabber in the Data Acquisition System that a particle was seen and this laser has fired by driving the PDS

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STATUS signal high. The PDS STATUS signal is received by the frame grabber and is used by the data acquisition system to determine whether or not the next image frame it receives contains at least one particle.

- State 3: The DSP is a microprocessor that resides in the sensor head of the CPI. Notify the digital signal processor (DSP) that a particle was seen so that it can send a PDS packet to the data acquisition system. A PDS data packet accompanies each particle image with particle-specific information. Wait in this state and do not allow any more particles to be imaged until an EXSYNC pulse is received from the frame grabber in the data acquisition system. The EXSYNC pulse causes the camera to download its current image to the data acquisition computer. It also tells the sensor head electronics that the camera and data acquisition computer are ready to take the next picture.
- State 4: Perform some of the operations to reset the sensor head electronics in preparation for the next particle. Wait for the CLEAR HOLD signal from the DSP. This signal tells the state machine that the DSP is ready for the next particle.
- State 5: If no particles are detected in the beam, go to state 0; otherwise, wait here.

The imaging laser will fire when the PIB_OK signal goes low. This causes the image of the particle to be captured by the CCD camera. The camera downloads the captured image to the frame grabber which is located in the Data Acquisition System as soon as it receives the next EXSYNC pulse from the frame grabber.

Once the image download is complete, the frame grabber interrupts the computer. Before the image was downloaded, the frame grabber checked the PDS STATUS signal to see if the imaging laser was fired. If it was not fired, then the PDS STATUS bit will be a logic low. In this case the image frame is discarded. If it was fired, the PDS STATUS signal will be a logic high. In this case, the image frame is searched for regions of interest (ROIs) by the CPI GUI.

ROIs are locations in the image where particles are present. The image processing algorithm subtracts the stored background image from the newly acquired frame. If the subtraction results in any areas of the CCD image greater than a predefined minimum pixel size with a shadow depth greater than a user selectable particle threshold, these areas are cropped from the full frame. **Figure 1.1.2** shows an example of an ROI that was cropped from the image frame. The ROIs are cropped from the picture and stored in the current data file on the hard disk. This keeps the data files as small and compact as possible.

As particles are detected, they are shown on the Image Display of the CPI Graphical User Interface (GUI). The 2D-S GUI displays the images recorded by the horizontal and vertical channels. **Figure 1.1.3** shows the two image displays side by side. Both images were taken

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at the same time, when the sample volume had spherical water droplets passing through. The elliptical shapes of the horizontal and vertical channels shows that the true air speed (TAS) was set too low, causing the electronics to sample too fast. When the TAS is set to the correct speed, one channel has a 10 micron pixel resolution, and the other 50 microns.

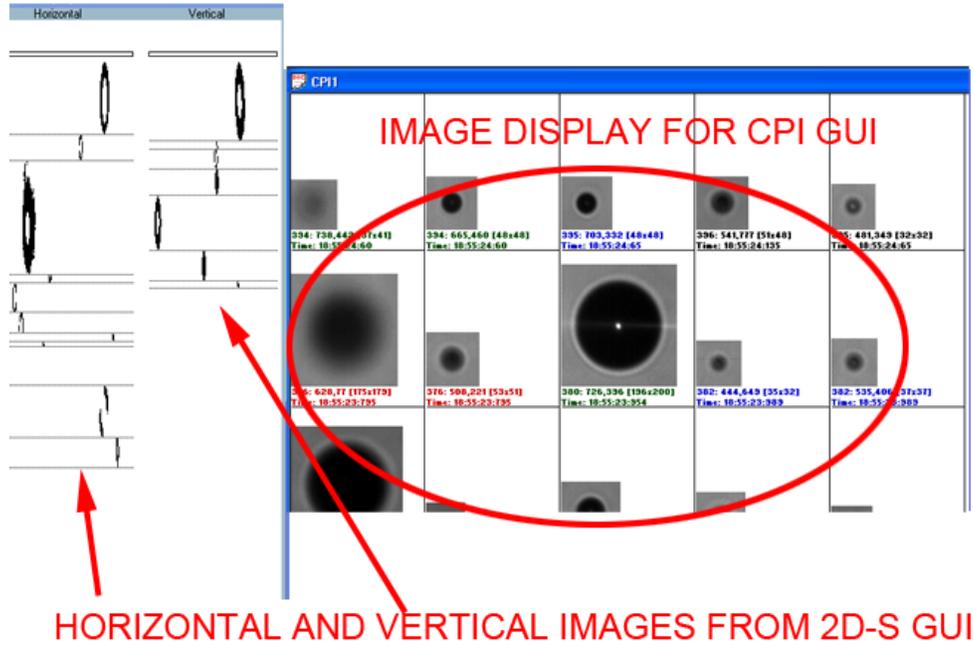


Figure 1.1.3. Image displays of CPI and 2D-S GUIs side by side.

1.2 Hawkeye FCDP

The Hawkeye Fast Cloud Droplet Probe (FCDP) determines particle size and concentration by measuring the amount of forward scattered light scattered by particles in the sample volume. The instrument sizes particles from 1-50 μm with a resolution of about 3 μm , and resolves these particles into twenty size bins. The FCDP is capable of sizing particles with velocities from 10-200 m/s. The FCDP is a stand-alone system with its own data acquisition system which stores data on a micro SD card. The instrument can interface with a computer inside the aircraft cabin or can be configured to turn on and store data automatically at power ON.

1.2.1 Main Components of the FCDP

The Hawkeye FCDP (shown in **Figure 1.2.1**) consists of the data acquisition system, which contains the electronics board, and the 533 MHz Samsung S3C2443 microprocessor based System on Module (SOM). The electronics board converts the analog voltages to digital form and this data is stored in FIFOs on the Field Programmable Gated Array (FPGA). The FPGA interfaces with the Signal, Qualifier, Housekeeping ADCs and the SOM. The SOM analyzes and processes the voltages corresponding to scattered light and classifies it in different particle size bins. This data, along with the housekeeping data, are saved in the form of 5 different files on the micro SD by the SOM. The SOM also provides Ethernet and RS232/422 interfaces for real time display and control by a remote computer.

The main body also contains the Power, Laser and Heater control board. The 28 VDC and 110 VAC inputs from the aircraft are distributed to the various components of the FCDP: laser, detector, detector amplifier board, data acquisition system and heaters, by the Power-laser-heater board. The board also controls the temperatures of the heaters.

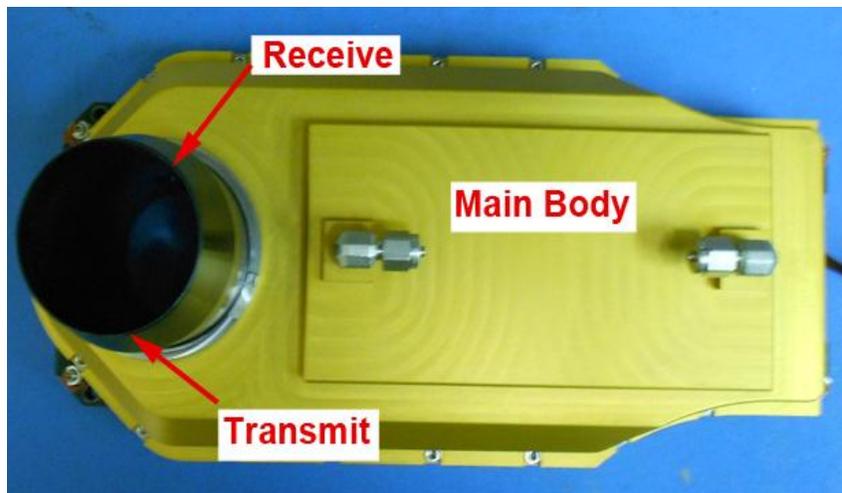


Figure 1.2.1. Hawkeye FCDP.

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1.2.2 Hawkeye FCDP Functional Overview

The Hawkeye Fast Cloud Droplet Probe (FCDP) determines particle size and concentration by measuring the amount of light scattered into the collecting optics aperture during particle interaction through a focused laser beam. A collimated, fiber-coupled laser is projected on the sample volume between the transmit and receive arms of the FCDP. Cloud particles in the sample volume scatter the laser beam. The light scattered by the cloud particles is collected at a dump spot on the receive arm. This beam is split into two detectors: qualifying and signal detectors. **Figure 1.2.2** is a diagrammatic representation of the principle of operation of the FCDP.

When a particle is in focus for both detectors, the slit based qualifier sees a high peak. Since a 50:50 beam splitter is used, the qualifier peak should be two times greater than the signal peak in order for a particle to be qualified, as shown in **Figure 1.2.3**.

Characteristics such as run time, transit time, signal voltage, qualifier voltage, area (sum of volts) and time to peak are recorded by the data acquisition system for each particle.

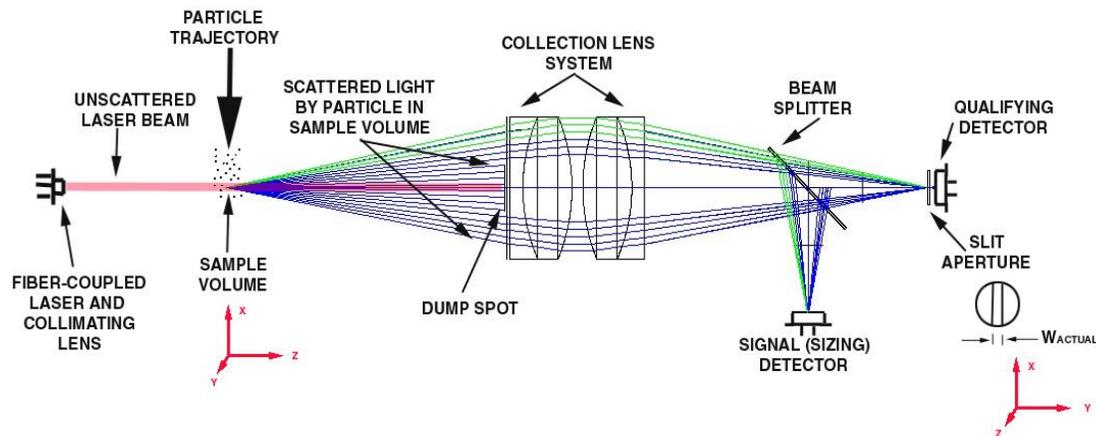


Figure 1.2.2 Diagrammatic representation of the principle of operation.

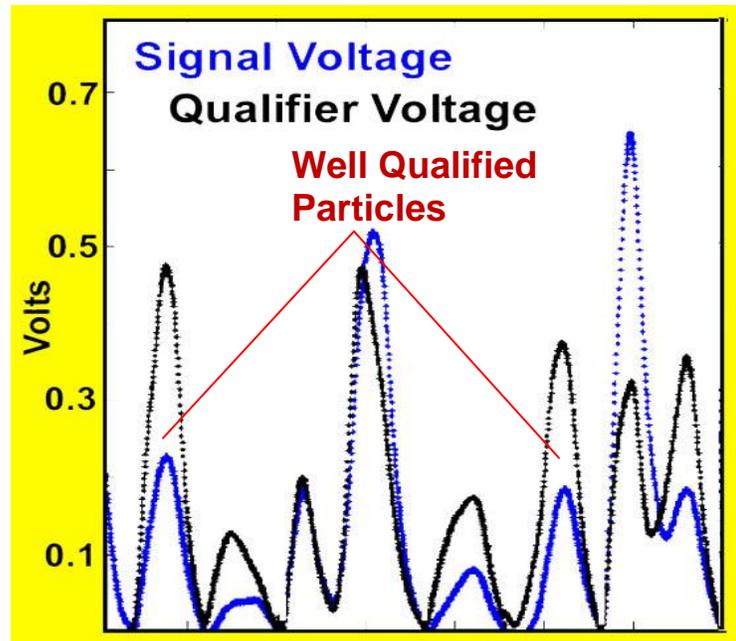


Figure 1.2.3. Examples of Qualified Particles

2 Getting Started

2.1 Unpacking the Hawkeye

This procedure is to be followed when unpacking the Hawkeye system after shipment or storage.

1. Open the shipping case containing the Hawkeye sensor head (**Figure 2.1.1**).
2. Remove the Hawkeye pylon from the shipping case and place on a padded surface (**Figure 2.1.2**).
3. Remove the pylon plug from the Hawkeye sensor head before operating (**Figure 2.1.3**). The pylon plug is used to keep contamination out of the Hawkeye sample tube during shipping. It should be reinstalled before the pylon is shipped.
4. Verify that the contents of both shipping containers match the contents on the included packing list.
5. The Hawkeye can now be connected following the Connection Procedure, **Section 2.2**.



Figure 2.1.1. Hawkeye sensor head in shipping case.

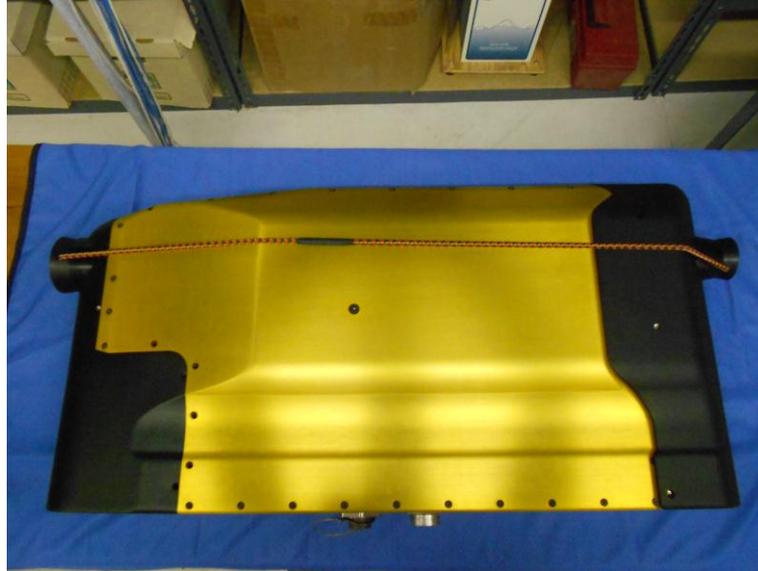


Figure 2.1.2. After removing sensor head from shipping case, place on a padded surface.

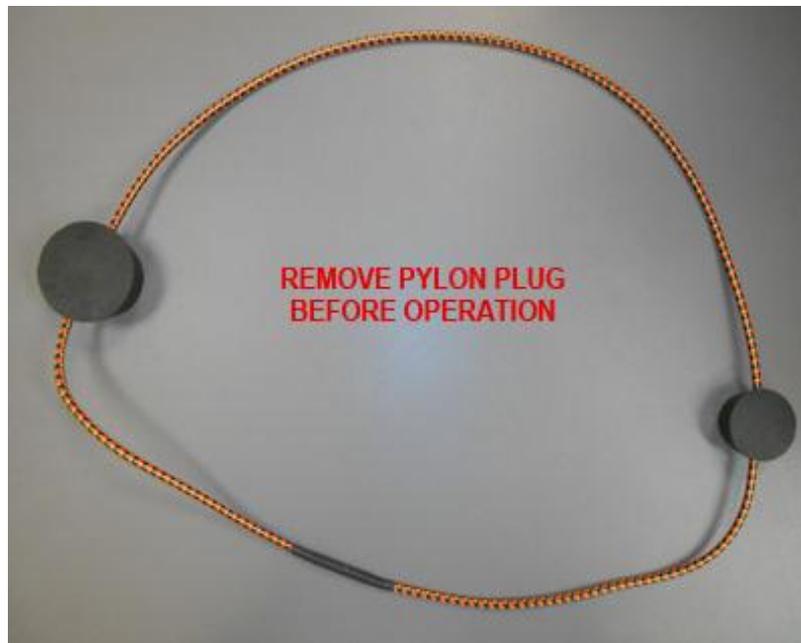


Figure 2.1.3. Pylon plug, removed from the Hawkeye sensor head before operation.

2.2 Connecting Hawkeye to Data Acquisition System

Warning! Cables **MUST** be connected in a certain sequence.
If you do not follow this sequence, you may damage your Hawkeye!

Warning! The Data Acquisition System and Sensor Power switch **MUST** be turned **OFF** before any cables are connected or disconnected. If you do not turn them off before connecting or disconnecting cables, you may damage your Hawkeye!

2.2.1 Connection Procedure for Operation in the Laboratory

1. Verify that the sensor power switch on the front of the Data Acquisition System (DAS) is turned off. Verify that the DAS computer is turned off.
See **Figure 2.2.1**: Front of the Data Acquisition System.
2. Connect the computer power, AC1, and AC2 power cables to a 115 Volt AC source. The order of connection of the AC power cables is not important.
Figure 2.2.2 shows the Hawkeye cable connection diagram and **Figure 2.2.3** shows the back of the DAS, including the function of each outlet.
3. Connect the power cable to J2 on the DAS.
See **Figure 2.2.2**: Hawkeye Cable Connection Diagram and **Figure 2.2.4**: Connecting power to the Data Acquisition System.
4. Connect the DSP Ethernet and RS-232 cords to the DAS. The left Ethernet connection is for the 2D-S, the right is for the FCDP
See **Figure 2.2.5**: Connecting DSP Ethernet cords to the Data Acquisition System.
5. Connect the power/DSP cable to J2 on the Pylon.
See **Figure 2.2.13**: Connecting the power/dsp cable to the Pylon.
6. Connect the framegrabber fiber optics converters to J1 on the DAS.
See **Figure 2.2.6**: Connecting the fiber converters to the DAS.
7. Assemble the power supply for the fiber converts.
See **Figure 2.2.7**: Assembling the power supply for fiber converters.
8. Connect the power supply to the fiber converters.
See **Figure 2.2.8**: Connecting the power supply to the fiber converters.
9. Remove the Rubber Caps from the fiber cables and the converters. Replace caps when cables and converters are disconnected.
See **Figure 2.2.9**: Removing caps from fiber and converters.

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10. Connect the framegrabber cables from the converters connected to J1 on the DAS to J1 on the sensor head.
See **Figure 2.2.10**: Connecting fiber cables to converters, and **Figure 2.2.14**: Connecting the sensor camera cable to the sensor head.
11. Connect the computer power, AC1, and AC2 to the back of the DAS.
See **Figure 2.2.2**: Hawkeye Cable Connection Diagram and **Figure 2.2.11**: Connecting the computer power and sensor AC1 & AC2 power.
12. Connect mouse, keyboard, and monitor to back of the DAS.
See **Figure 2.2.3**: Back of the Data Acquisition System.
13. Connect the 28 VDC power cord to the back of the DAS.
See **Figure 2.2.12**: Connecting 28 VDC to back of Data Acquisition System.
14. The Hawkeye is now ready to be powered up.

2.2.2 Connection Procedure for Installation on an Airplane

1. Verify that the Sensor Power switch on the front of the Data Acquisition System (DAS) is turned off. Verify that the DAS computer is turned off.
See **Figure 2.2.1**: Front of the Data Acquisition System.
2. Connect the computer power, AC1, and AC2 power cables to a 115 Volt AC source. The order of connection of the AC power cables is not important.
Figure 2.2.2 shows the Hawkeye cable connection diagram and **Figure 2.2.3** shows the back of the DAS, including the function of each outlet.
3. Connect the mouse, keyboard, and monitor to the back of the DAS.
See **Figure 2.2.2**: Hawkeye Cable Connection Diagram and **Figure 2.2.3**: Back of the Data Acquisition System.
4. Connect the power cable and DSP Ethernet cords to J2 on the DAS only. The left DSP connection is for the 2D-S, the right is for the FCDP. DO NOT connect the other end to the sensor head yet.
See **Figure 2.2.4**: Connecting the power to the Data Acquisition System and **Figure 2.2.5**: Connecting the DSP Ethernet cords to the Data Acquisition System.
5. Connect the sensor camera fiber optics to J1 on the DAS only. DO NOT connect the other end to the sensor head yet.
See **Figures 2.2.6 - 2.2.10**.

6. **BEFORE** making connections to the sensor head, electrostatic discharge (ESD) precautions should be taken:
 - Hawkeye mounted on aircraft: It is assumed that if the Hawkeye sensor head is mounted on the aircraft, the Hawkeye pylon is grounded to the aircraft frame. It is also assumed that if the Data Acquisition System (DAS) is mounted in a metal frame inside the aircraft, that it is also grounded to the aircraft frame. In this case, no extra ground wire is needed.
 - Hawkeye not mounted or if the DAS is not mounted: a temporary ground wire should be run between the Hawkeye pylon and the DAS Chassis. If the DAS Chassis is grounded to the aircraft frame, then the ground wire may alternatively be run from the pylon to the aircraft frame.
 - This will ensure that the sensor head and the DAS Chassis are at the same electrical potential when the cables are connected. The person making the cable connections should also be grounded to the Hawkeye pylon by using a ground strap or by touching a screw on the outside of the Hawkeye pylon.
7. Connect the power/DSP cable that runs from J2 on the DAS to J2 on the sensor head. See **Figure 2.2.13**: Connecting the power/DSP cable to the sensor head.
8. Connect the sensor camera cable that runs from J1 on the DAS to J1 on the sensor head. See **Figure 2.2.14**: Connecting the sensor camera cable to the sensor head.
9. Remove the temporary ground wire that was installed in step 6.
10. The Hawkeye is now ready to be powered up, as described in Section 2.3.

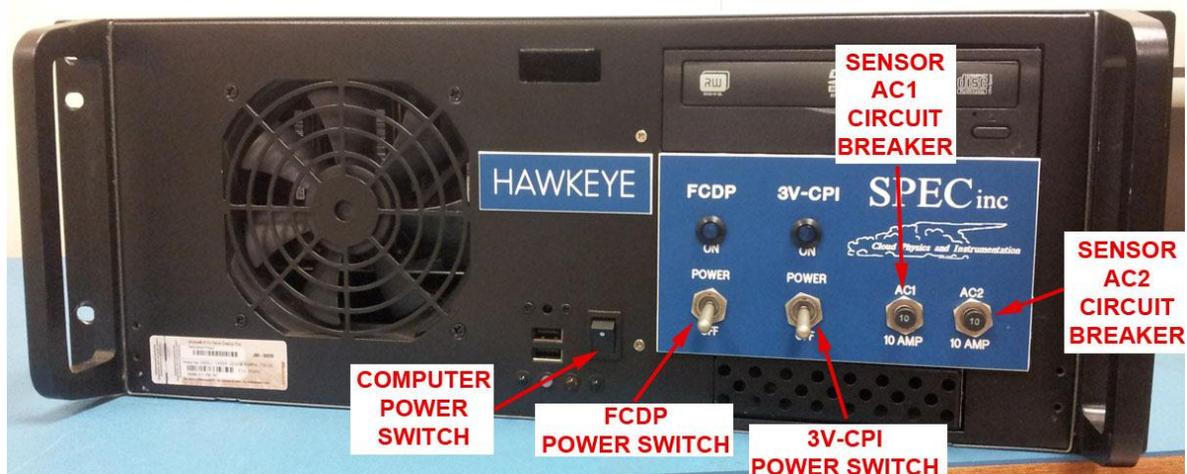


Figure 2.2.1. Front of the Data Acquisition System (DAS).

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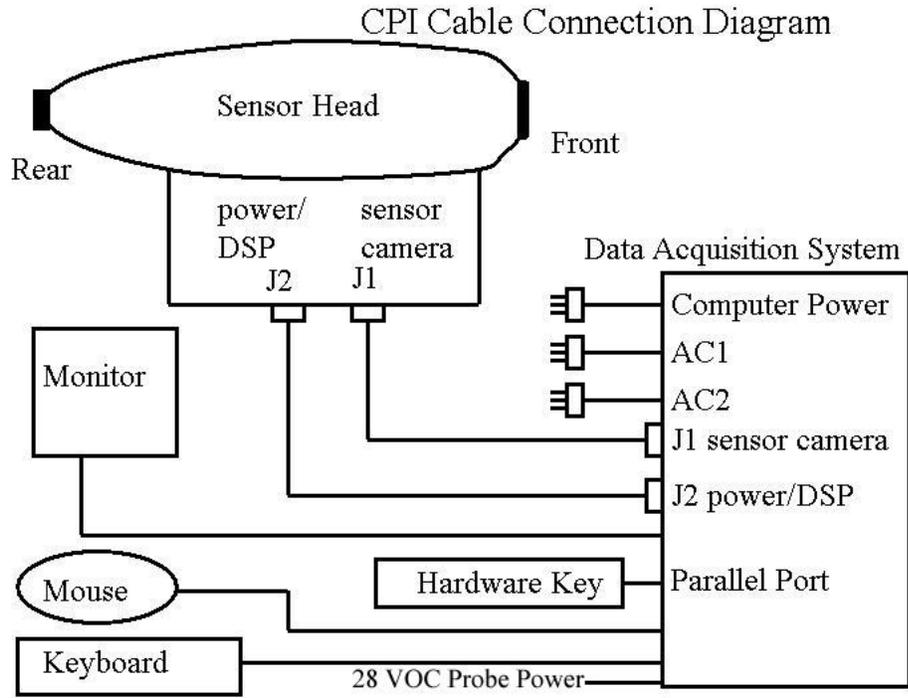


Figure 2.2.2. CPI Cable Connection Diagram.

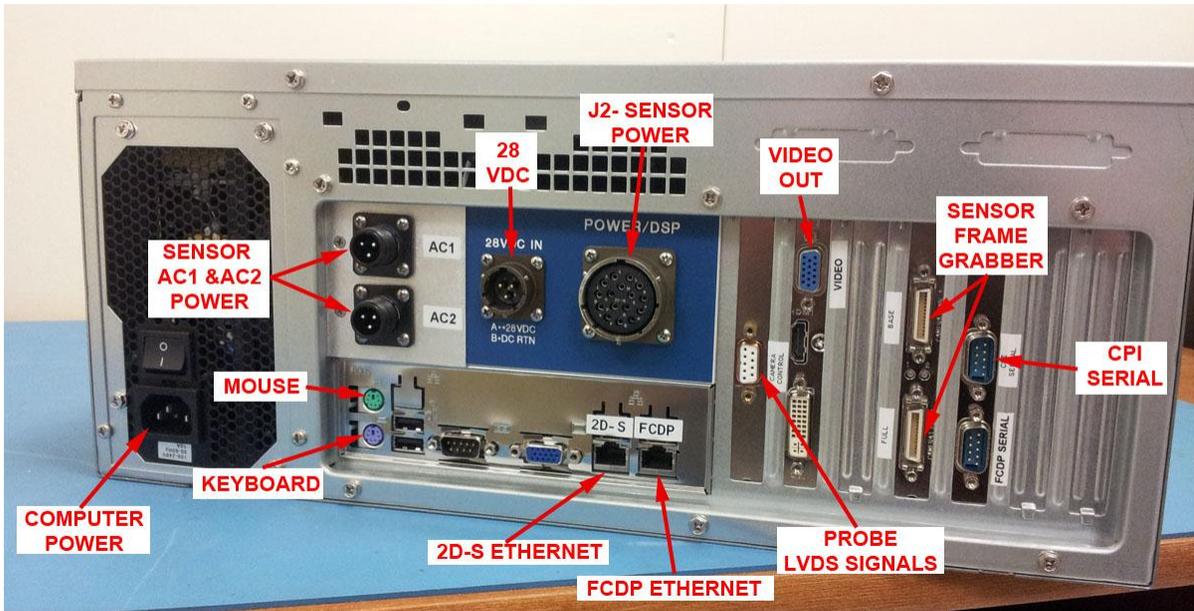


Figure 2.2.3. Back of the DAS (note: monitor outlet not pictured).

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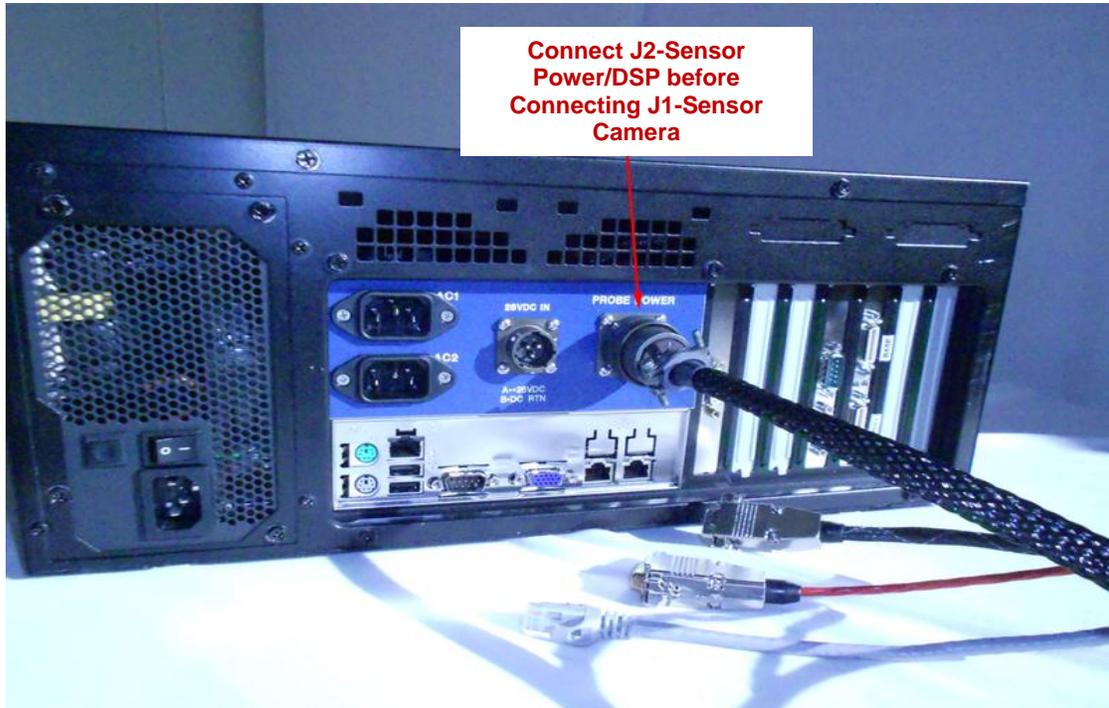


Figure 2.2.4. Connecting the power to the Data Acquisition System (DAS).

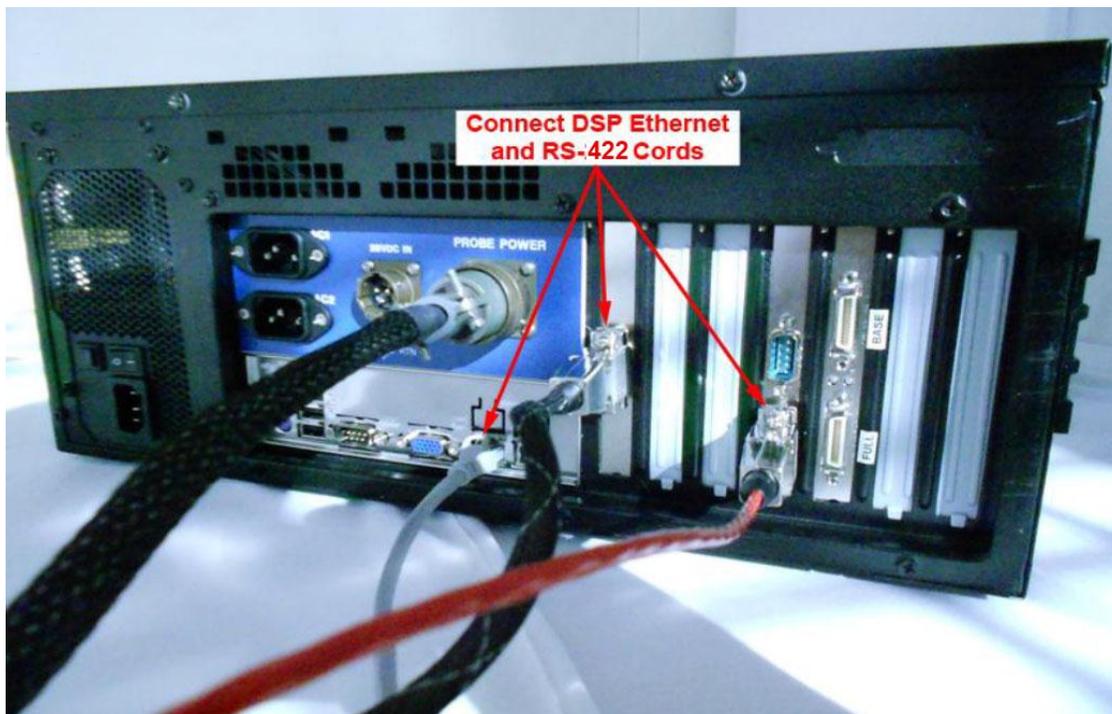


Figure 2.2.5. Connecting the DSP to the DAS (note: there are two Ethernet connections, the left is for the 2D-S, the right for the FCDP, both should now be connected).

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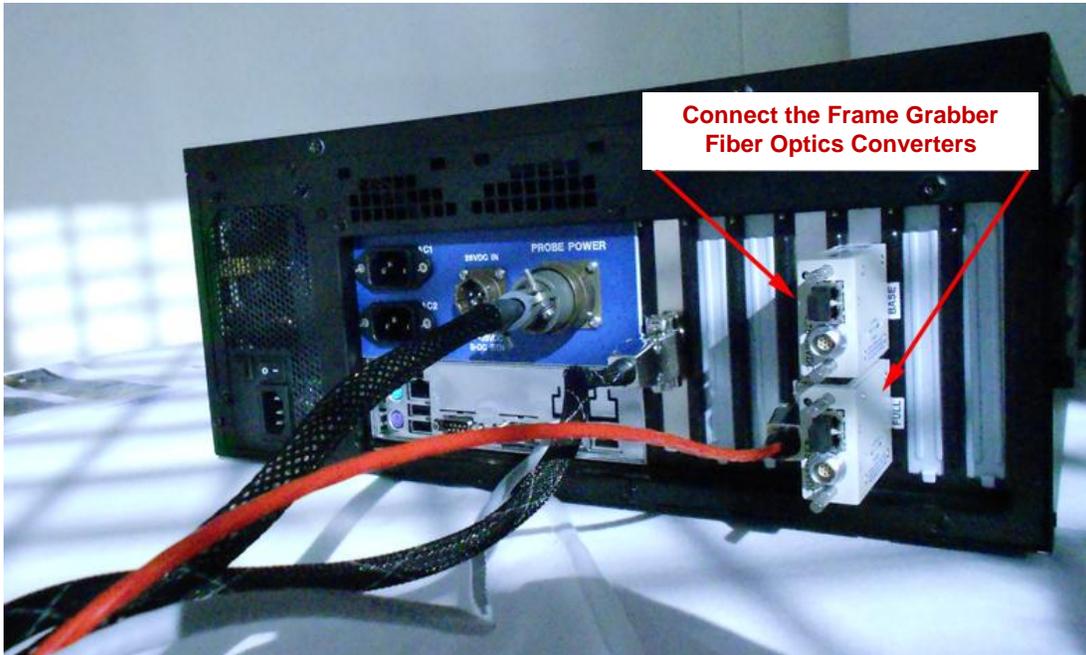


Figure 2.2.6. Connecting the fiber converters to the DAS.

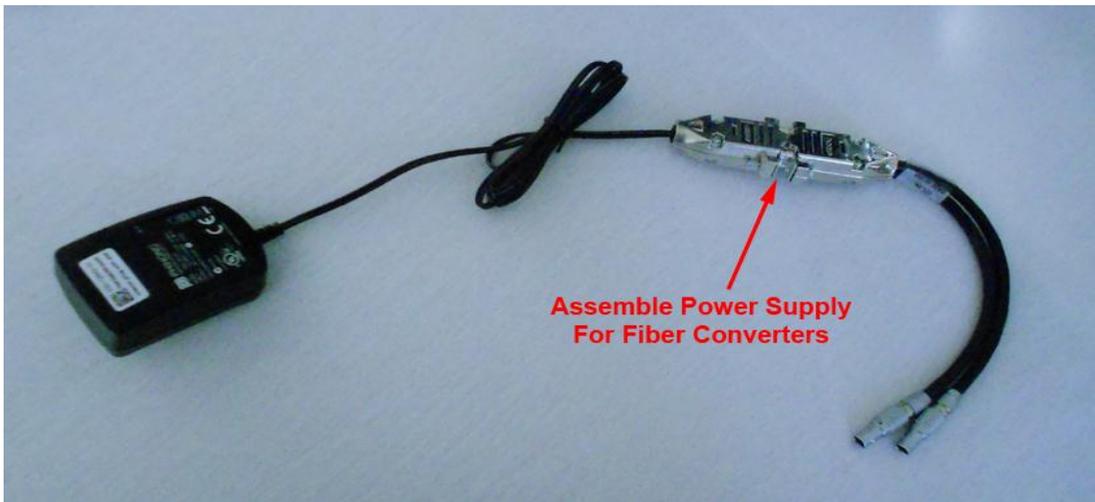


Figure 2.2.7. Assembling the power supply for fiber converters.

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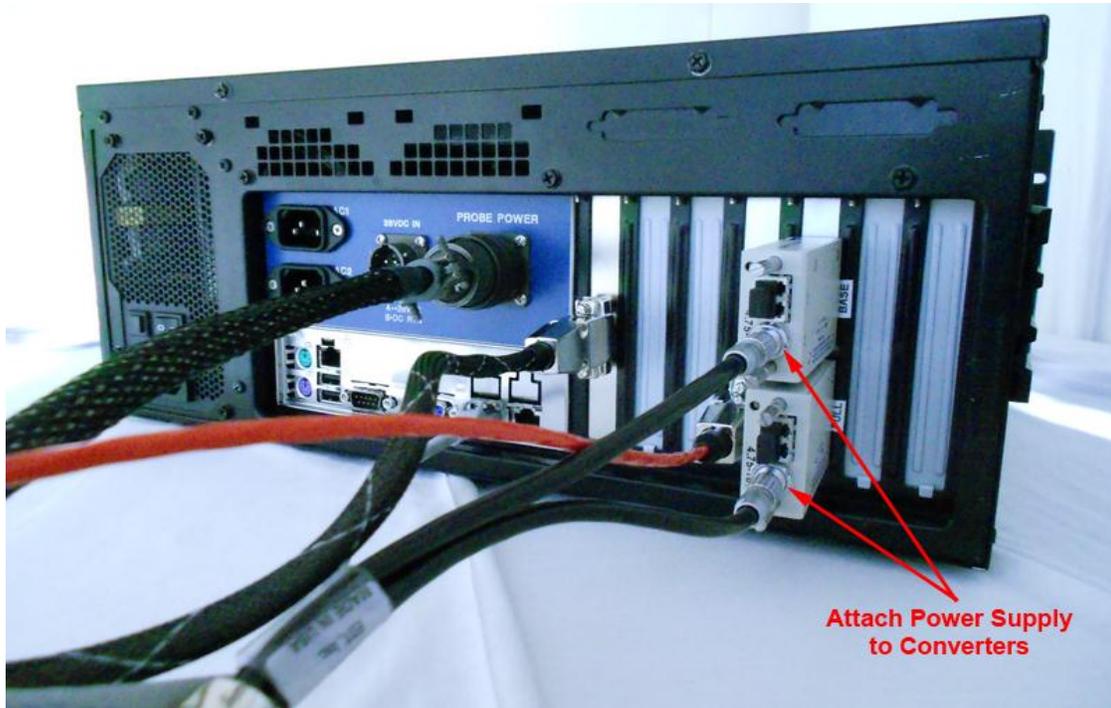


Figure 2.2.8. Connecting the power supply to the fiber converters.

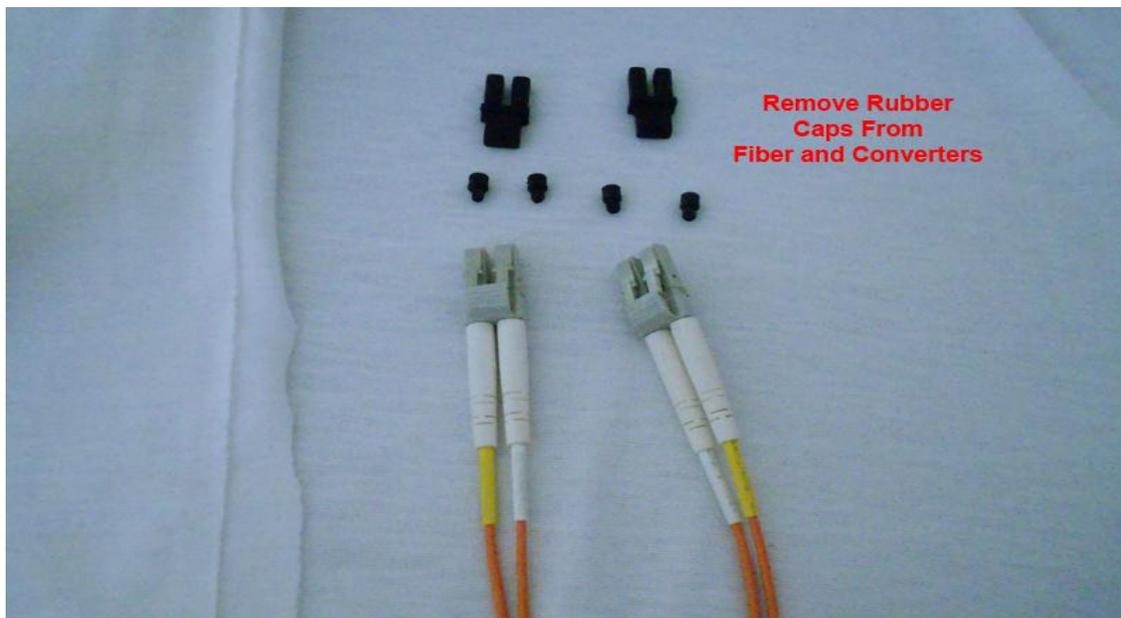


Figure 2.2.9. Removing caps from fiber cables and converters.

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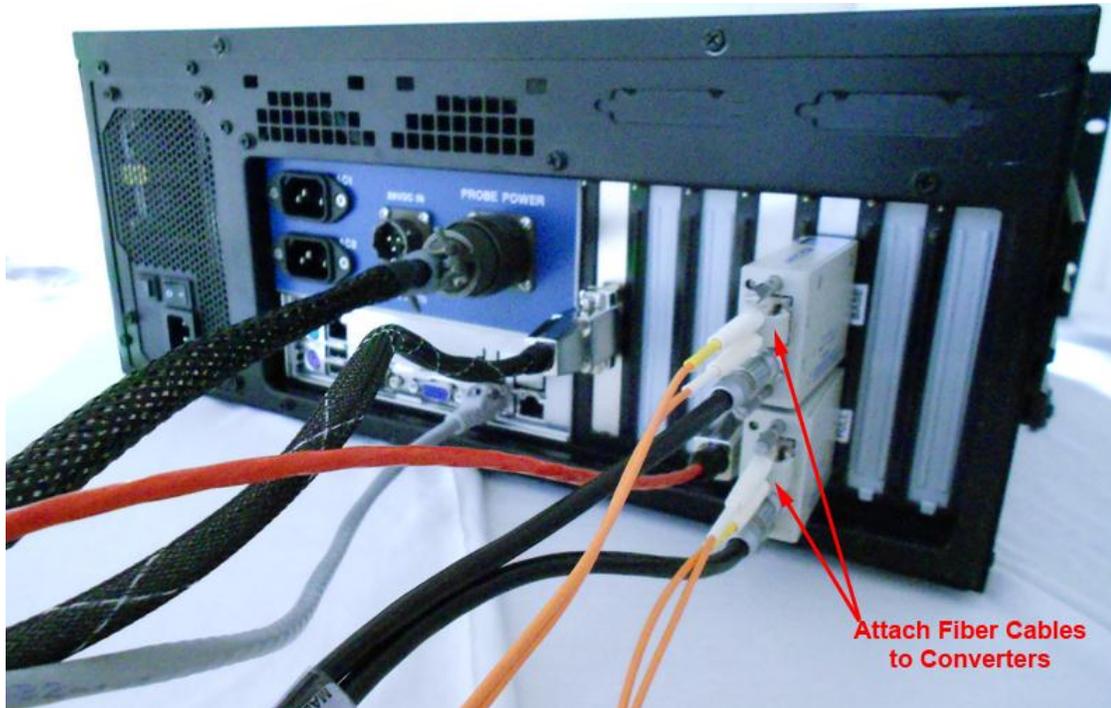


Figure 2.2.10. Attaching fiber cables to converters.

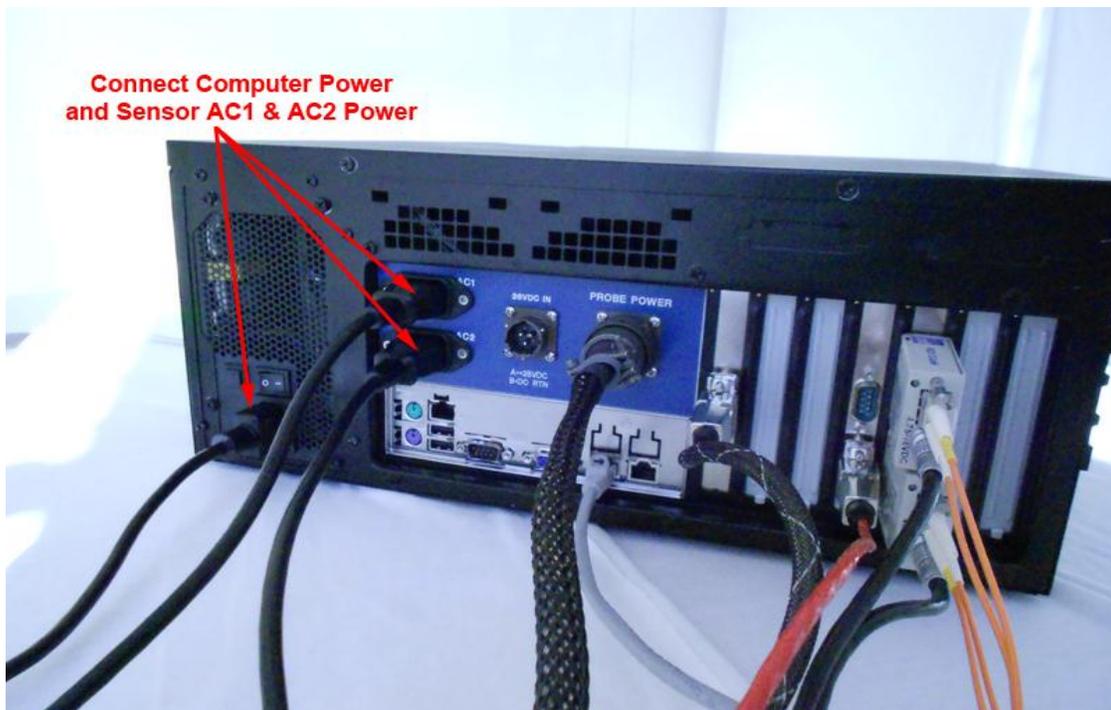


Figure 2.2.11. Connecting the DAS power and sensor AC1 & AC2 power.

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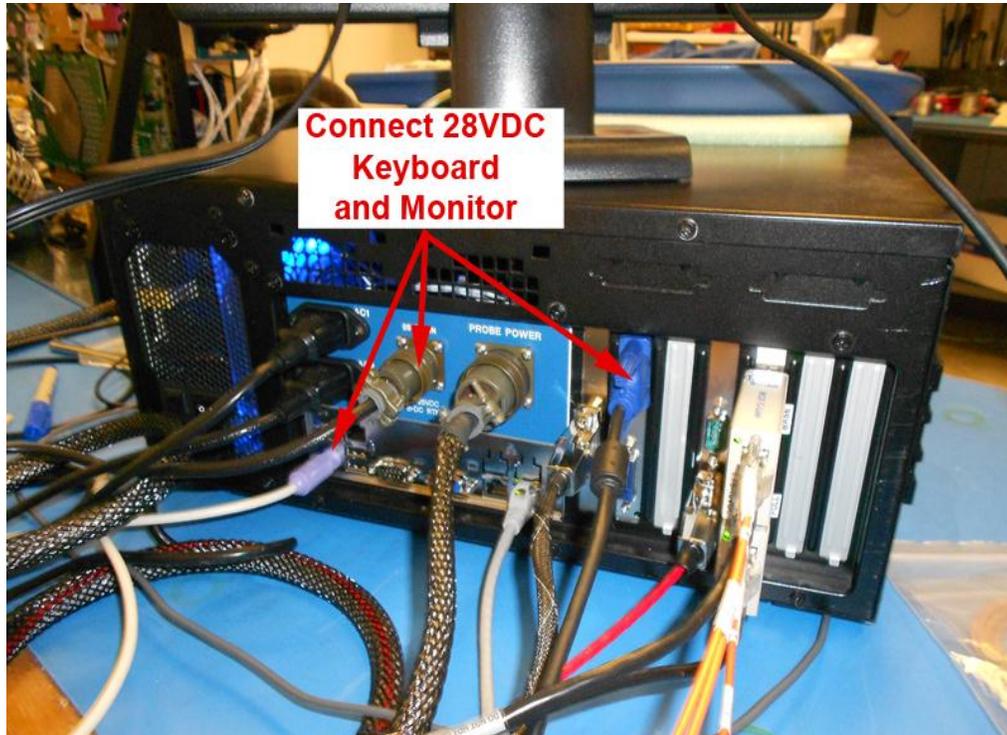


Figure 2.2.12. Connecting 28 VDC, keyboard, and monitor to back DAS.

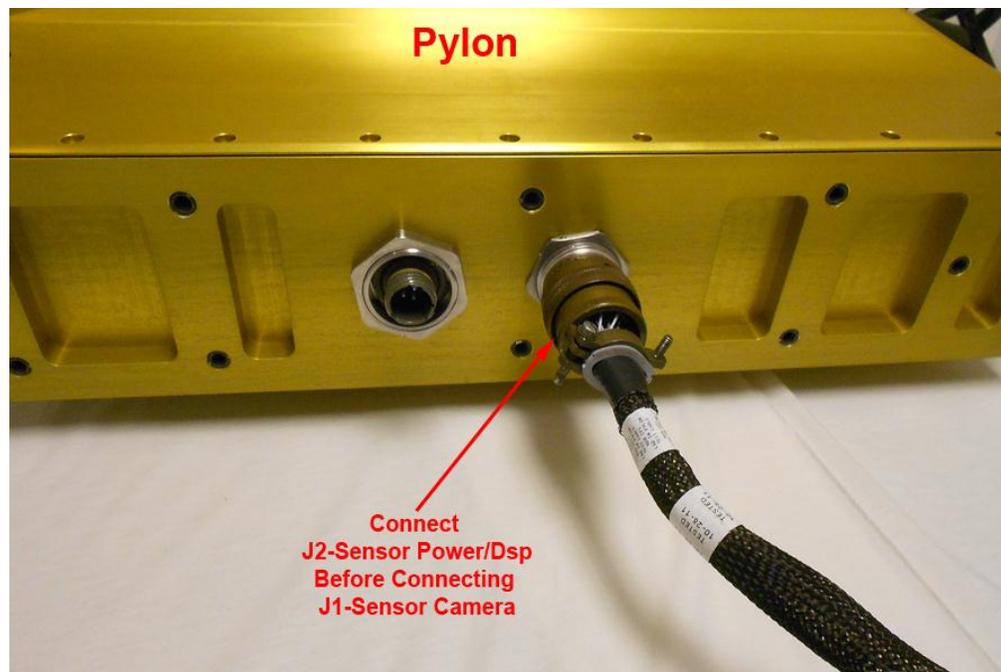


Figure 2.2.13. Connecting the power/DSP cable to the sensor head.

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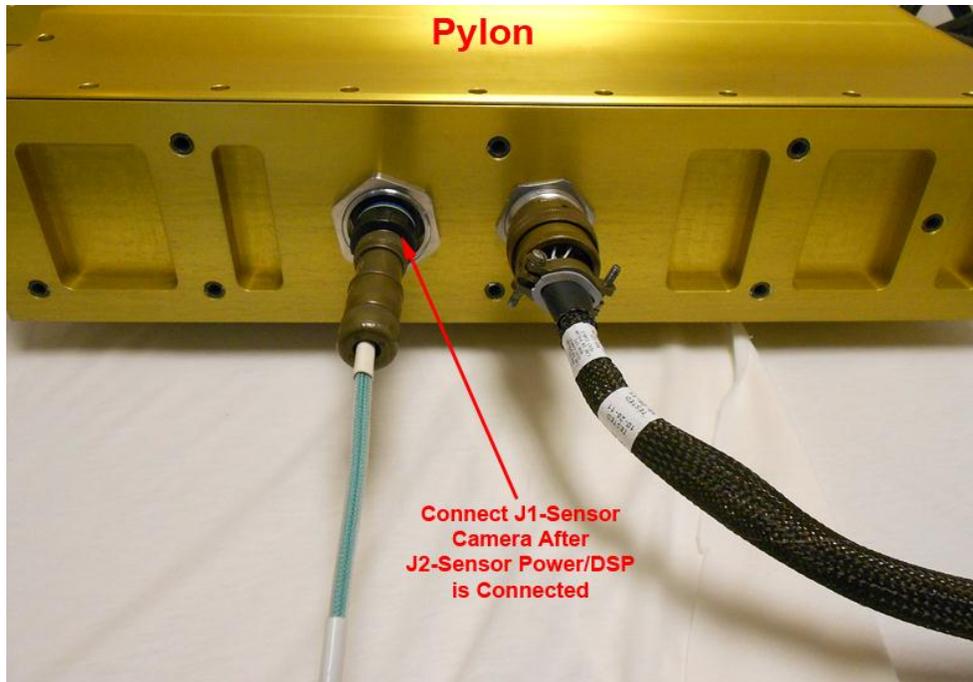


Figure 2.2.14. Connecting the sensor camera cable to the sensor head.

2.3 Hawkeye Startup Procedure

1. Verify that all cables are connected according to Section 2.2, “Connecting Hawkeye to Data Acquisition System.” See **Figure 2.3.1**.



Figure 2.3.1. Hawkeye DAS with all cables connected.

2. Start the Data Acquisition System (DAS) computer by pressing the computer power switch on the lower center side of the computer (see **Figure 2.3.2**). Allow the computer to boot up.

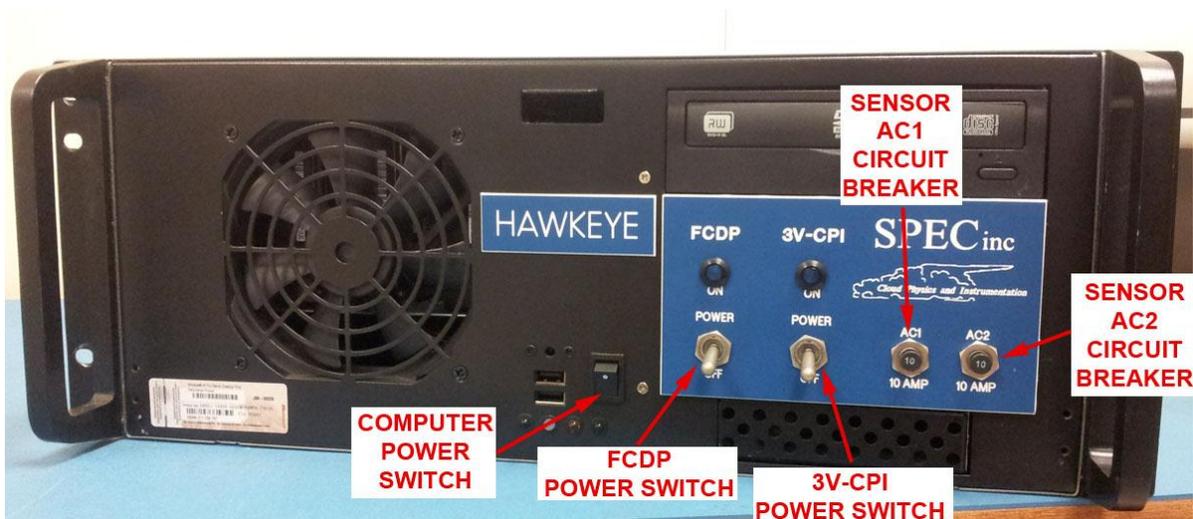


Figure 2.3.2. Front panel of the Hawkeye DAS.

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3. On the computer desktop, double click the CPI, 2D-S, and FCDP icons to start each respective GUI¹. Note: See the Operational Software Manual for more detail on operating the software.
4. After the programs have started, switch on the sensor power switch on the front panel of the DAS (see **Figure 2.3.2**).

Connecting to the CPI probe

5. Single click the Start Probe button on the left side on the CPI GUI window² (see **Figure 2.3.3**).

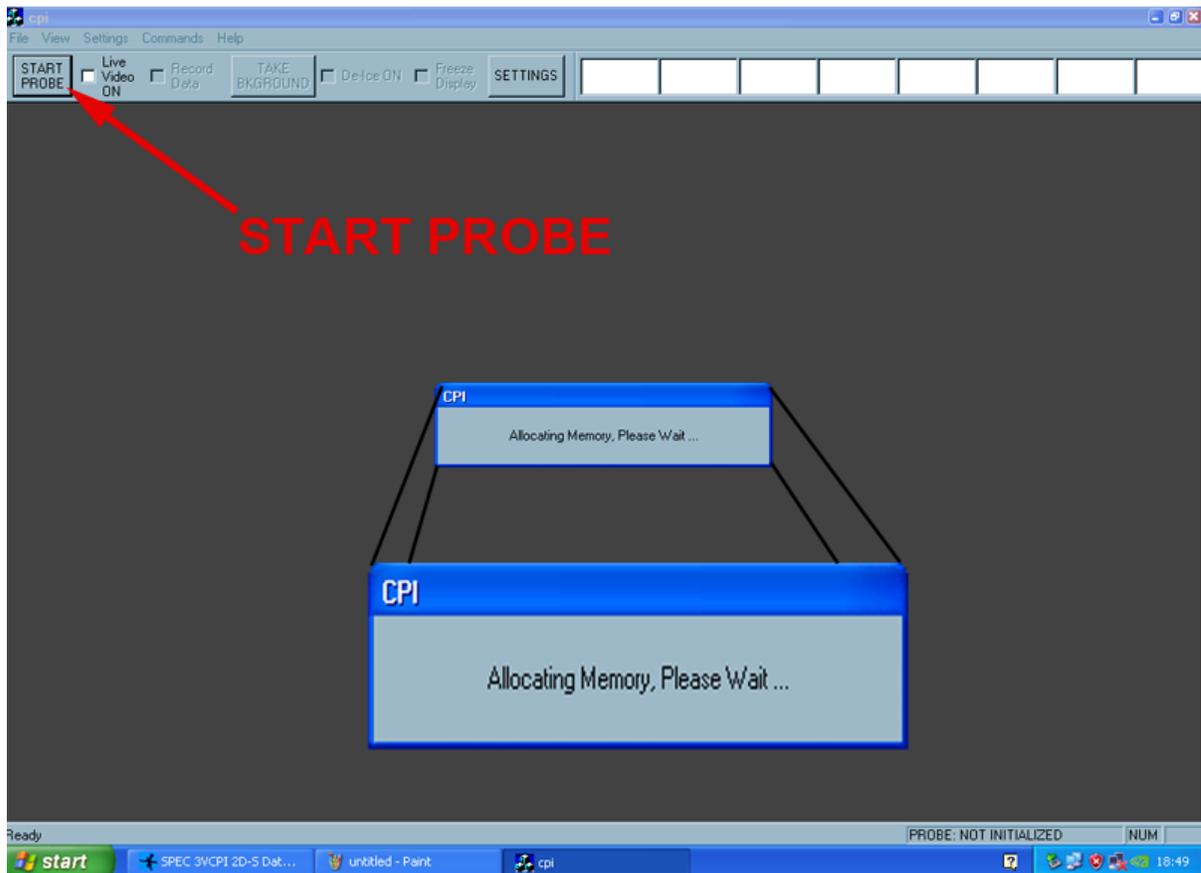


Figure 2.3.3. CPI GUI screen while it is allocating memory.

6. In the CPI GUI, you should see an “Allocating Memory” message as shown in **Figure 2.3.3**. This message indicates that the CPI GUI is allocating memory locally in the DAS computer. It is not yet trying to communicate with the probe (sensor head). Wait about forty seconds.

¹ Each GUI may run simultaneously and independently of each other.

² This will turn on both components of the probe since the CCD requires the 2D-S laser array to operate.

7. After about forty seconds, the message window should change to “Initializing the Probe...” as shown in **Figure 2.3.4**. In this step, the CPI GUI tries to communicate with the probe. If it is successful, it sets up probe operating values, receives data packets from the probe, directs the CCD camera to take two background images, and processes those images to establish a background reference for the probe’s imaging system.

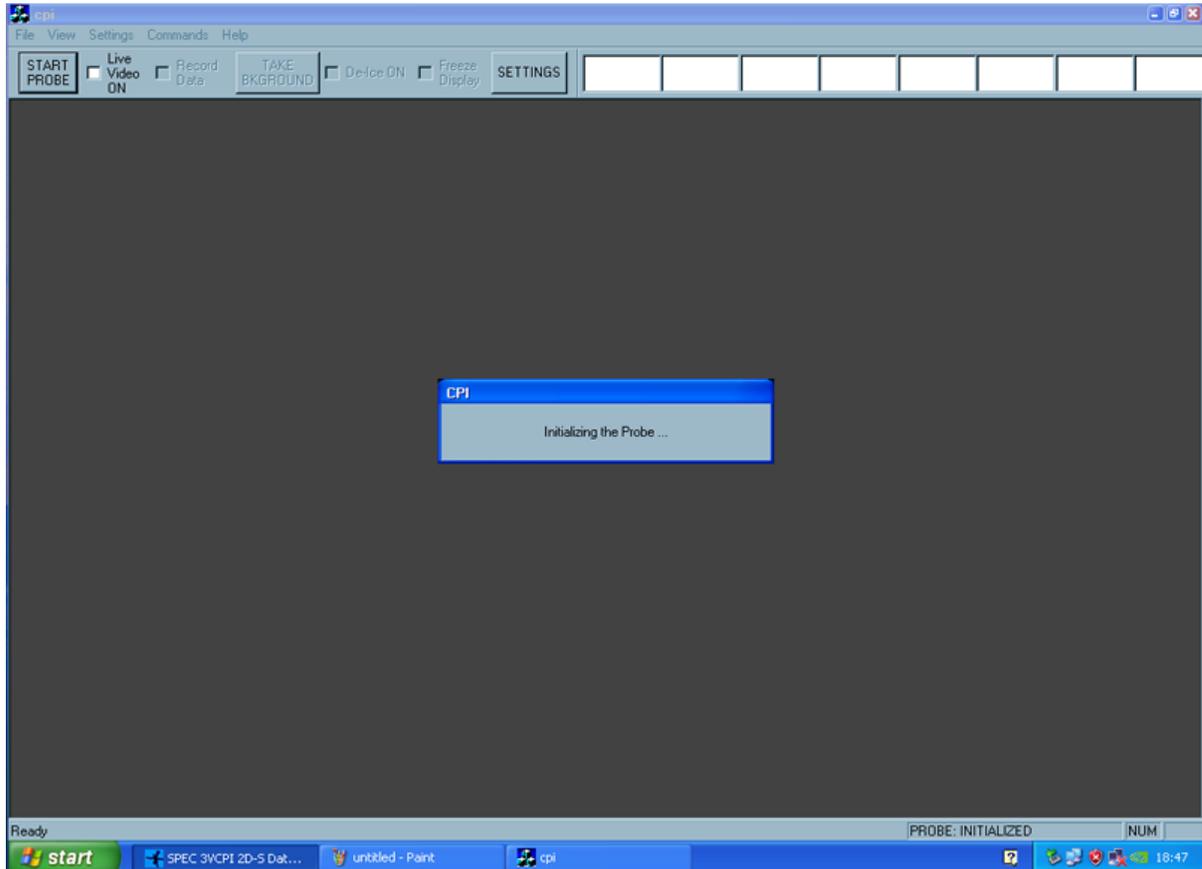


Figure 2.3.4. CPI GUI screen while it is initializing the probe.

8. After about ten more seconds, you should see the CPI startup screen, as seen in **Figure 2.3.5**. This contains a particle image display window with at least one background image. You should see a “Statistics” window on the right-hand side of the screen, as shown in **Figure 2.3.5**. If you see a screen like **Figure 2.3.5**, then your Hawkeye has been started correctly and is running. See the “Software Description and Real Time Operation, **Section 4**) for further instructions on fine-tuning and running your Hawkeye.

If you DO NOT see a screen like **Figure 2.3.5**, then the software or probe has a problem. Review the Hawkeye cable connection procedure and Hawkeye startup procedure to make sure that they were done correctly. If these procedures were followed correctly, then please see the “Real Time Operation and Troubleshooting, **Section 3.2**).

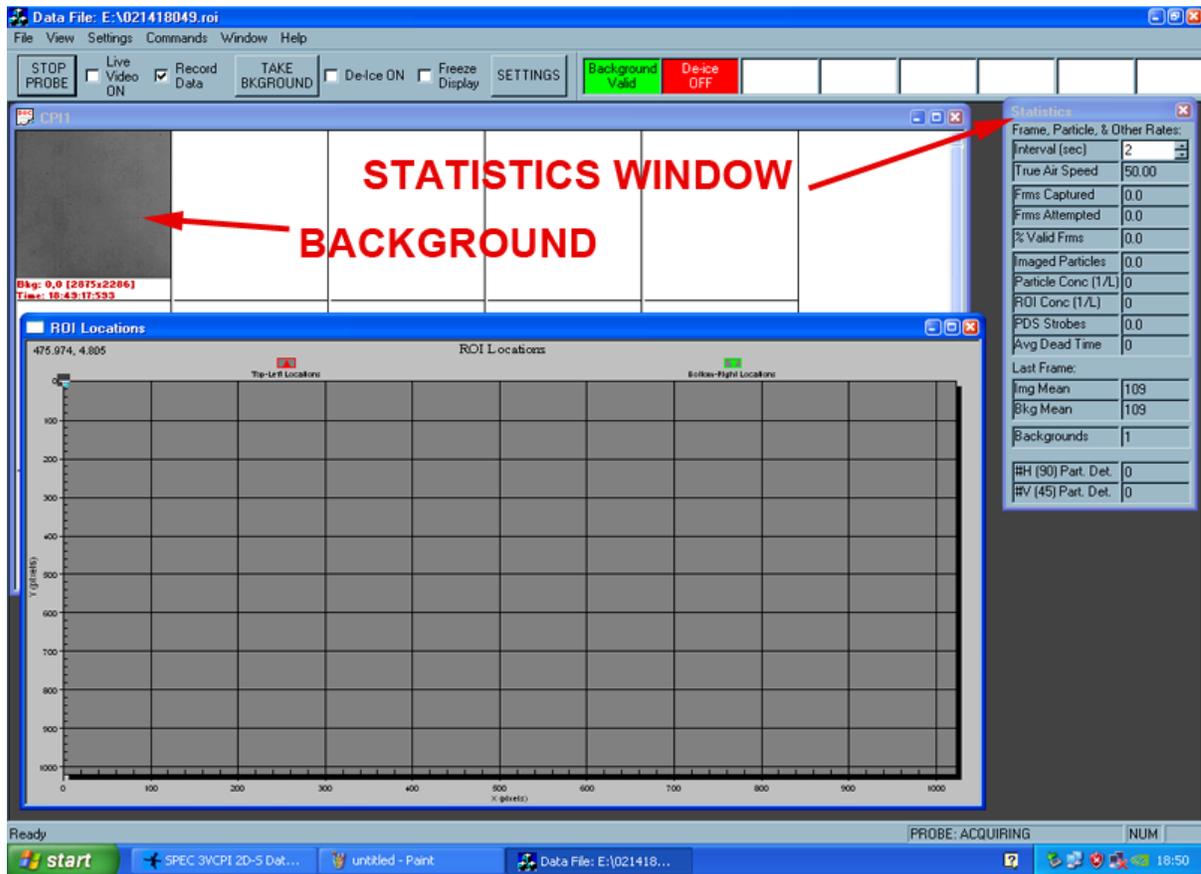


Figure 2.3.5. Startup screen of CPI GUI.

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Connecting to the 2D-S probe

- To initialize the connection between the 2D-S GUI and the probe, click the red arrow in the top left corner of the 2D-S GUI display window (**Figure 2.3.6**). Make sure to press the **red** arrow; pressing the black arrow results in monitoring the probe, but not saving any of the data.

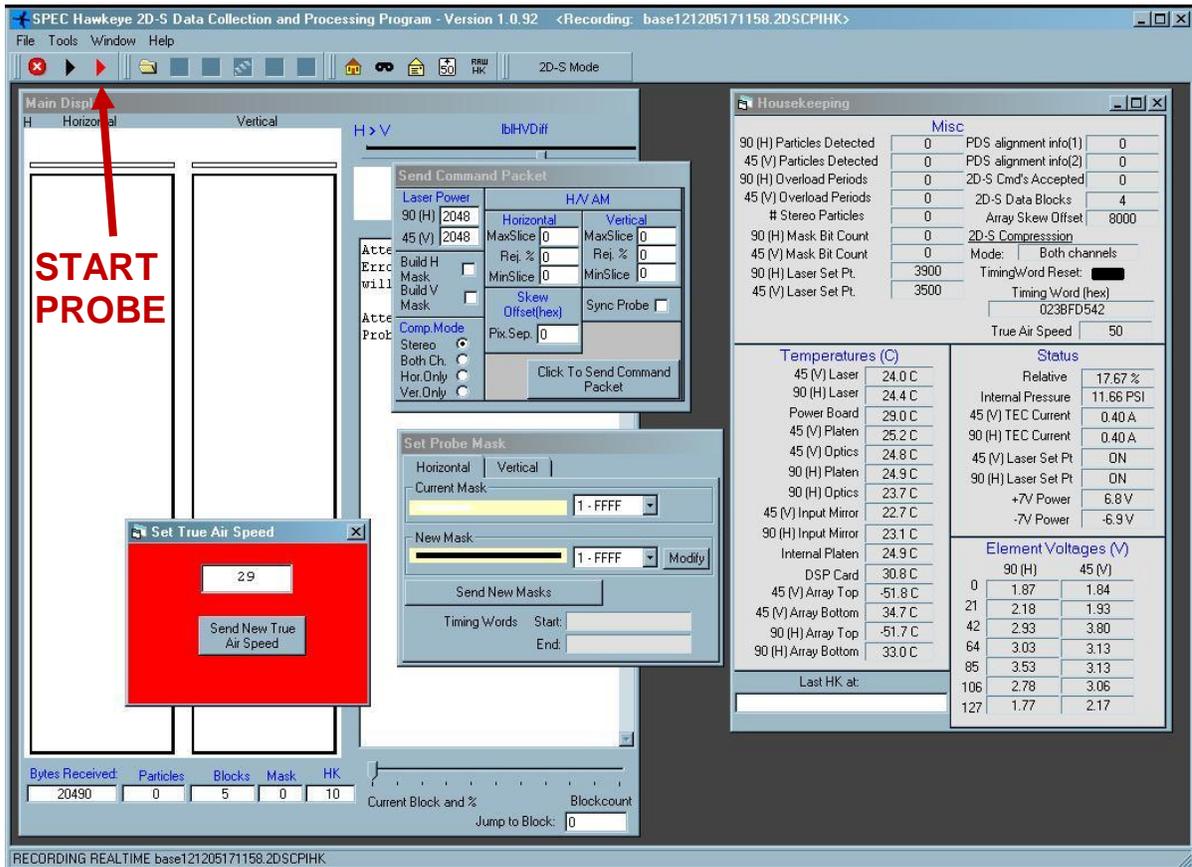


Figure 2.3.6. Startup screen for 2D-S GUI.

Connecting to the FCDP

10. To initialize the connection between the FCDP GUI and the probe, click the green “Connect to Probe” button shown in Figure 2.3.7. This will connect and time sync the probe.
11. Once the network connection has been established, type `df -h /mnt/hda` in the “SSH Command Field”, then click the “Send String” button to check the amount of available flash disk space and ensure there is sufficient memory available.
12. Click the green “Start” button (may take around 60 seconds before the display updates).
13. The system is now ready for Real-Time Operation, detailed in the software manual.

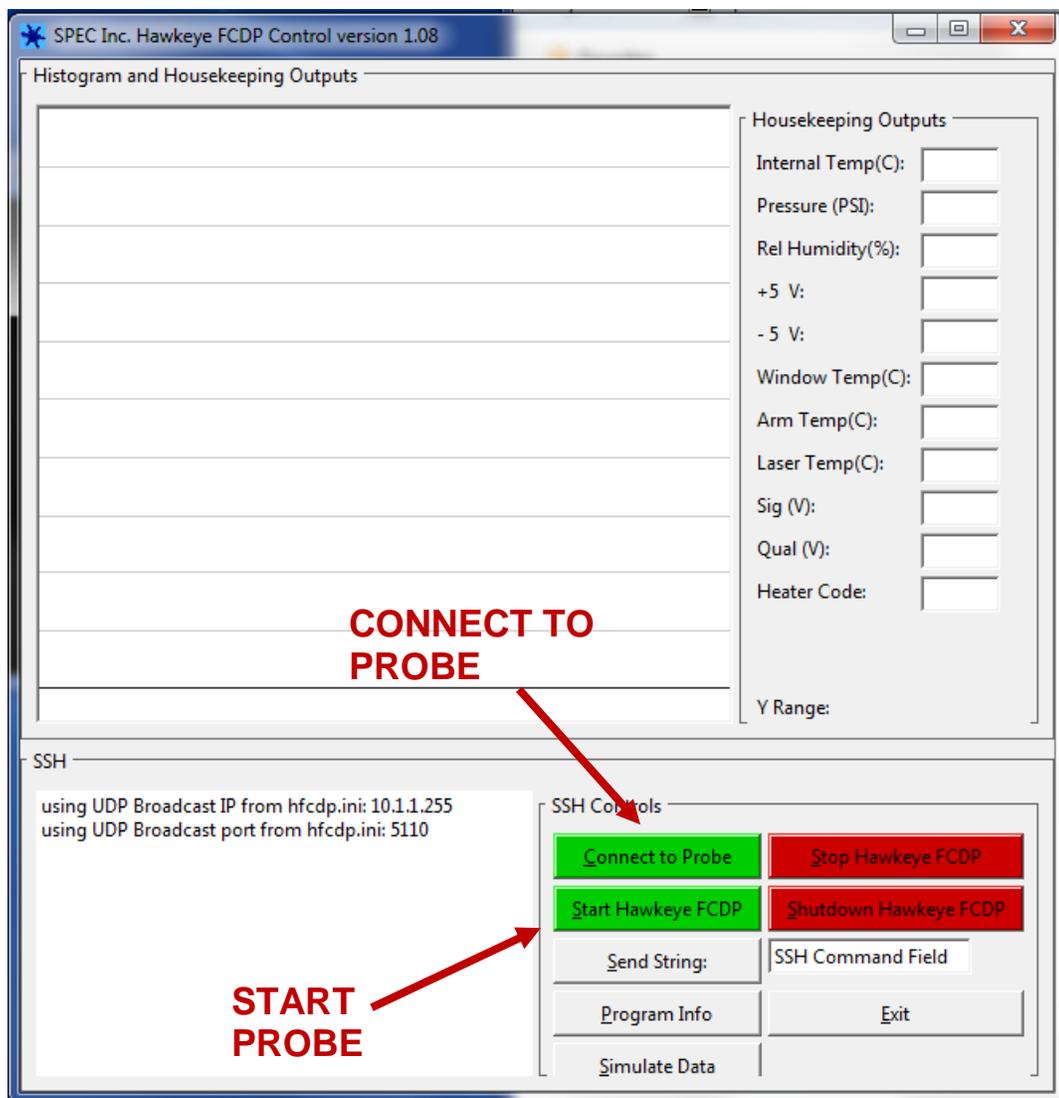


Figure 2.3.7. Startup screen for Hawkeye FCDP GUI.

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2.4 Hawkeye Shutdown Procedure

Disconnecting from the CPI probe

1. To disconnect from the CPI, click the Stop Probe button in the upper left-hand corner (see **Figure 2.3.5**). Once stopped, the CPI GUI window may be closed.

Disconnecting from the 2D-S probe

2. To disconnect from the 2D-S, click the button with the red circle with an x button (see **Figure 2.3.6**). Once stopped, the 2D-S GUI window may be closed.

Disconnecting from the FCDP

3. To disconnect from the FCDP, click the “Stop Hawkeye FCDP” button (see **Figure 2.3.7**).
4. Once the FCDP has stopped collecting data, click the “Shutdown Hawkeye FCDP” button. Once stopped, the FCDP GUI window may be closed.

Shutting Down the System

5. After the programs have been closed, switch off the sensor power switch on the front panel of the DAS (see **Figure 2.3.2**).
6. Shut down the Data Acquisition System (DAS) computer. When it has shut down, turn off the computer power switch on the lower center side of the computer.
7. Once the system has been shut down, it may be disconnected following the procedure in the next section.

2.5 Disconnecting the Hawkeye

The Hawkeye cables must be disconnected in the reverse of the sequence in which they were connected:

1. Verify that the sensor power switch on the front of the Data Acquisition System (DAS) is switched off. Verify that the DAS computer is switched off.
2. Disconnect the sensor camera fiber cables from the converters on the DAS computer.
3. Disconnect the sensor camera cable from J1 on the sensor head.
4. Disconnect the DSP RS-232 and ethernet cords on the DAS computer.
5. Disconnect the power cable from J2 on the DAS computer.
6. Disconnect the power/dsp cable from J2 on the sensor head.
7. Disconnect the mouse, keyboard, and monitor from the back of the DAS computer.
8. Disconnect the three AC power cables: computer power, AC1, and AC2.

2.6 Packing the Hawkeye

This procedure is to be followed when packing the Hawkeye system for shipment or storage.

1. Place the pylon plug over the inlet and outlet of the Hawkeye pylon to keep dust out during shipping (**Figure 2.6.1**).
2. Place the Hawkeye sensor head in the shipping container. Be sure the sensor head is in the same orientation as in **Figure 2.6.2**. Close and latch the shipping case.
3. The Hawkeye is now ready for storage or shipping.

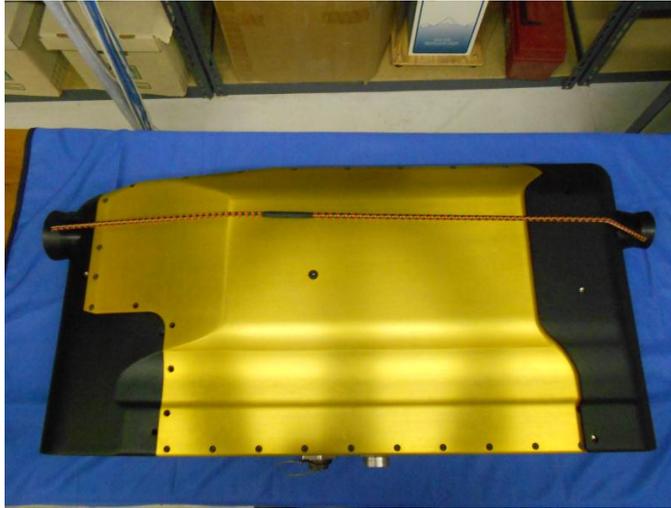


Figure 2.6.1. Place the pylon plug over the Hawkeye inlet and outlet.



Figure 2.6.2. Placement of the Hawkeye, with plug in place, in shipping container.

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3 Maintenance Procedures

3.1 Purging and Fairing Removal

Before every flight it is important to purge the Hawkeye sensor head and the Hawkeye FCDP, especially when in tropical climates. Both probes are hermetically sealed but moisture laden air may seep into the pylon over time because the cover is not installed correctly or other reasons. Purging the Hawkeye is done with Nitrogen gas or Extra Dry Air for about ten minutes. The correct procedure is as follows:

3.1.1 Purging the Pylon through the Rear Fairing

Items Required

- 9/64" hex key
- 1/2" wrench (or crescent wrench)
- 9/16" wrench (or crescent wrench)
- N₂ or Extra Dry Air cylinder with regulator outfitted with 1/4" tubing and 1/8" compression fittings
- Two stage regulator
- Flow meter
- Pressure relief valve

Rear Fairing Removal

1. Remove the six #8-32 socket head cap screws using the 9/64" hex key fastening the rear fairing. Note where the screws are located as they are not all the same length. See **Figure 3.1.1**.

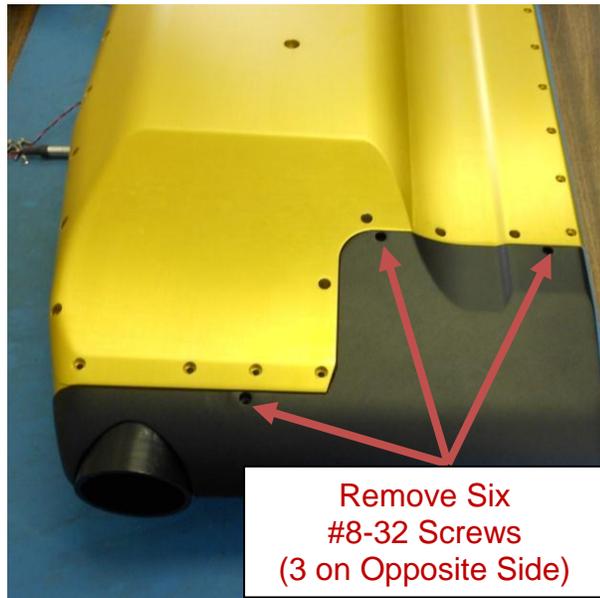


Figure 3.1.1: Screw locations for fairing removal required for purging.

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- Slide rear fairing off of Hawkeye as in **Figure 3.1.2**.

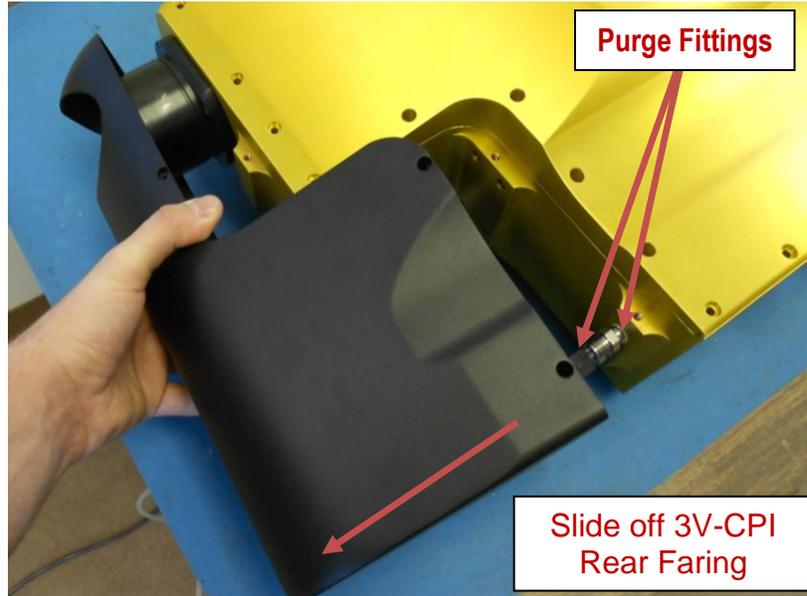


Figure 3.1.2: Sliding the rear fairing off of body, exposing fittings.

Purging the Instrument through the Rear Fairing

- Remove caps from purge fittings. Using the 1/2" wrench hold the inner fitting on the lower hex nut in place. Use the 9/16" wrench (or crescent wrench) to loosen the cap. **Figure 3.1.3** illustrates proper wrench placement. **Neglecting the inner fitting on the lower hex nut risks breaking the hermetic seal.**

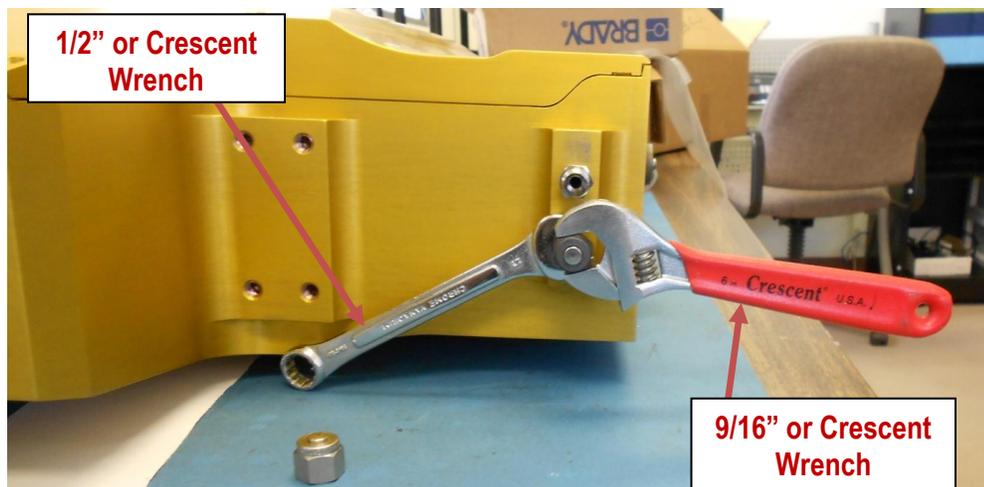


Figure 3.1.3: Use the 1/2" wrench on the nut most near the body to hold fitting. Use the 9/16" wrench on the cap. **DO NOT BREAK THE SEAL ON FITTING WHEN REMOVING CAP.**

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4. Attach the 1/4" tubing to one of the fittings on the rear plate. Tighten the compression fitting until it is finger tight. Leave the other fitting uncapped. **Figure 3.1.4** shows the proper configuration for connecting the gas. Use a gas cylinder with a two stage regulator, flow meter and pressure relief valve set to 0.5 psi. **Do not exceed 0.5 psi while purging.**
5. Begin flowing gas to displace any moisture laden air within the instrument. The typical purge cycle is flowing gas at 10-15 SCFH (5 lpm) for about 10 minutes.
6. Unhook the tubing from the fitting.
7. Reinstall caps and tighten with 9/16" wrench while using a 1/2" wrench to hold the fitting in place.

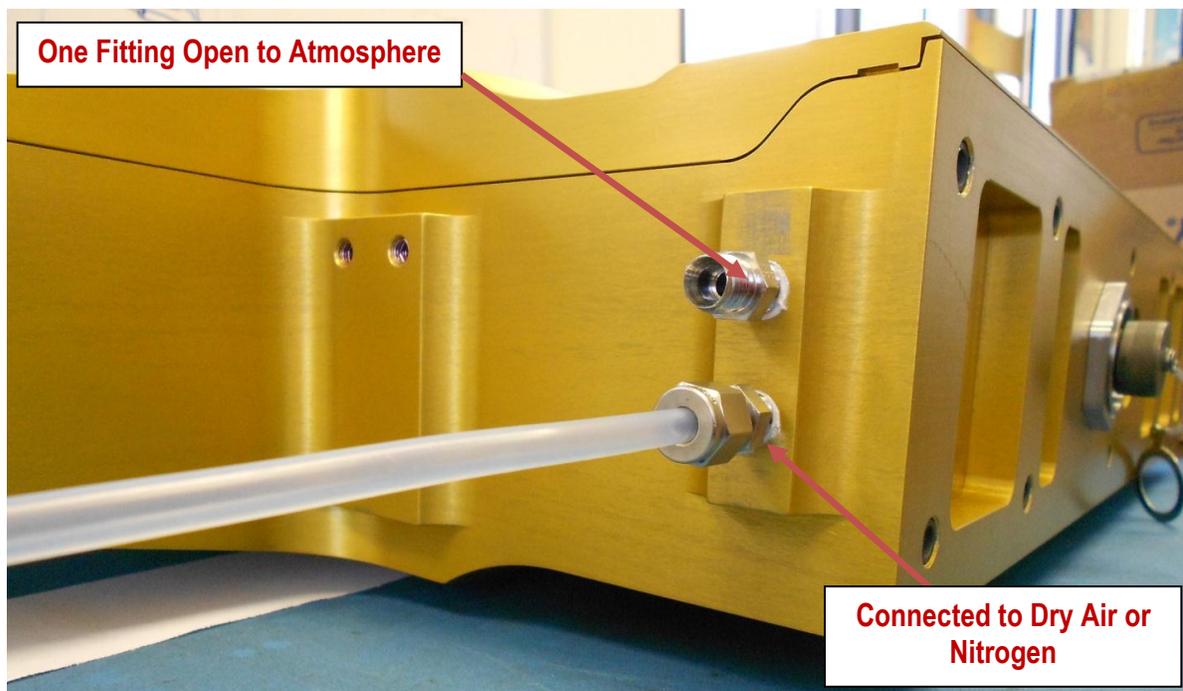


Figure 3.1.4: Proper purging configuration. One fitting is open to the atmosphere; the other is connected to the tube with compressed air flowing through. Do not flow at a rate greater than 10 lpm, do not let the internal pressure exceed 0.5 psi.

Rear Fairing Replacement

8. Replace the rear fairing. Use the 9/64" hex wrench and the six socket head cap screws previously removed in **Figures 3.1.1** and **3.1.2**

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3.1.2 Purging the FCDP through the Front Fairing

Items Required

- 9/64" hex key
- 1/2" wrench (or crescent wrench)
- 7/16" wrench (or crescent wrench)
- N₂ or Extra Dry Air cylinder with regulator outfitted with 1/4" tubing and 1/8" compression fittings
- Two stage regulator
- Flow meter
- Pressure relief valve

Front Fairing Removal

1. **Figure 3.1.5** shows the locations of the 6 #8-32 front fairing fasteners. There are three on each side. The top screws on either side are 3/8", and the bottom two on both sides are 5/8".
2. Remove all 6 fasteners using a 9/64" Allen-wrench.

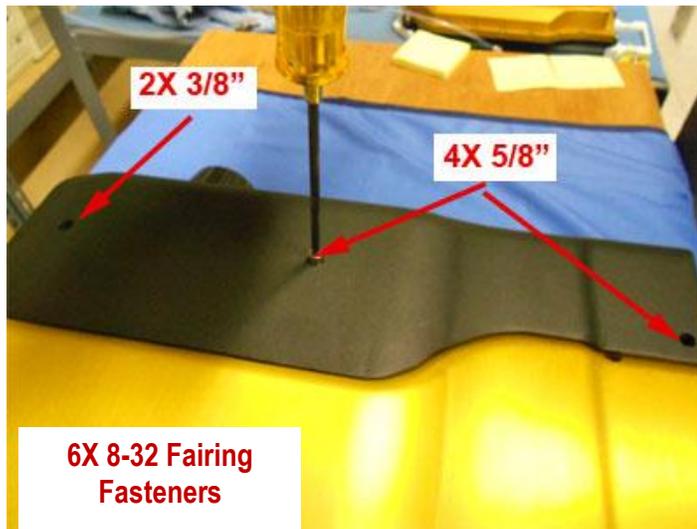


Figure 3.1.5. Placement of 3 of the Fairing Fasteners (the other three are on the bottom side of the pylon).

3. After the fairing fasteners are removed, slide the fairing directly away from the pylon, as in **Figure 3.1.6**. **DO NOT remove more than a few inches**. The heater in the front fairing is directly connected to the pylon, as well as the grounding wire.



Figure 3.1.6. Remove the Front Fairing by sliding it a few inches straight forward.

4. Once the fairing is removed slightly, place directly in front of the pylon so that the heater may be disconnected, and the grounding wire removed. **Figure 3.1.7** shows the front fairing heater cable being disconnected and **Figure 3.1.8** shows the grounding cable being detached.



Figure 3.1.7. Prior to complete removal of the Front Fairing, unplug the heater connector.

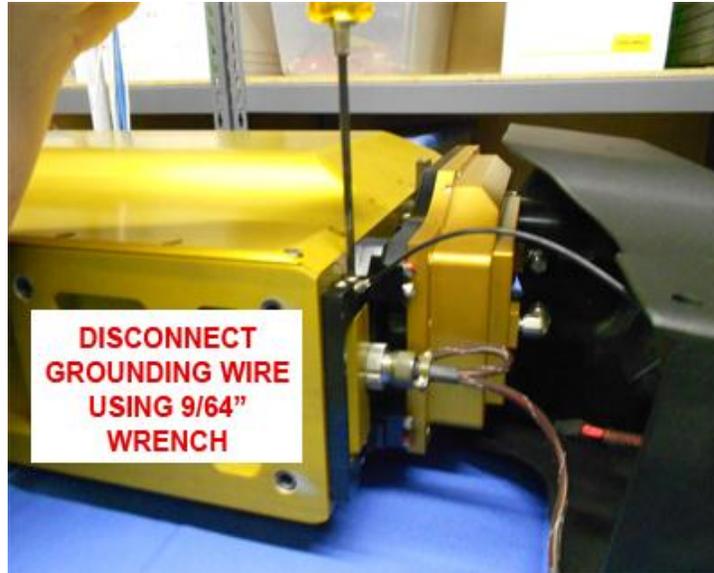


Figure 3.1.8. Prior to complete removal of the Front Fairing, disconnect the grounding wire.

Purging the FCDP

1. Remove caps from purge fittings. Using the 1/2" wrench hold the lower hex nut in place. Use the 7/16" wrench (or a crescent wrench) to loosen the cap. **Figure 3.1.9** illustrates proper placement of the 7/16" wrench. **Neglecting the inner fitting on the lower hex nut risks breaking the hermetic seal.**



Figure 3.1.9: Use the 1/2" wrench on the nut most near the body to hold fitting. Use the 7/16" wrench on the cap. **DO NOT BREAK THE SEAL ON FITTING WHEN REMOVING CAP.**

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2. Attach the 1/4" tubing to one of the fittings on the rear plate. Tighten the compression fitting until it is finger tight. Leave the other fitting uncapped. **Figure 3.1.10** shows the proper configuration for connecting the gas. Use a gas cylinder with a two stage regulator, flow meter and pressure relief valve set to 0.5 psi. **Do not exceed 0.5 psi while purging.**
3. Begin flowing gas to displace any moisture laden air within the instrument. The typical purge cycle is flowing gas at 10-15 SCFH (5 lpm) for about 10 minutes.
4. Unhook the tubing from the fitting.
5. Reinstall caps and tighten with 7/16" wrench while again using the 1/2" wrench to hold the fitting in place. **Neglecting the inner fitting on the lower hex nut risks breaking the hermetic seal.**

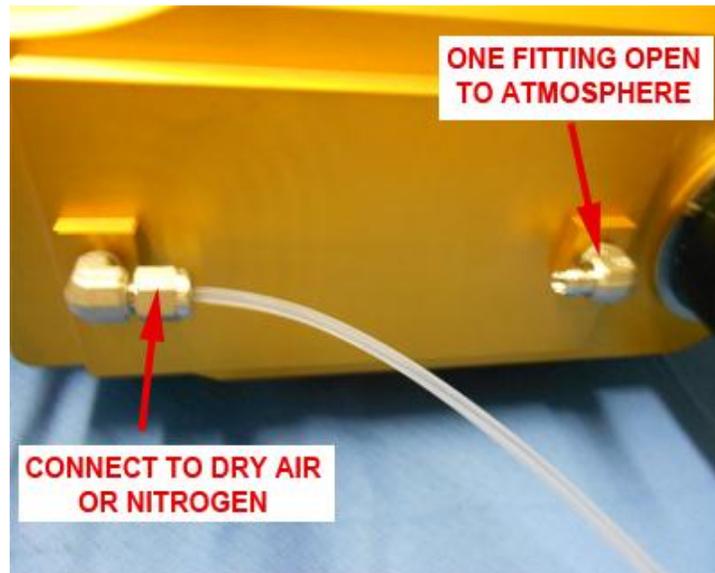


Figure 3.1.10: Proper purging configuration. One fitting is open to the atmosphere; the other is connected to the tube with compressed air flowing through. Do not flow a rate greater than 10 lpm, do not let the internal pressure exceed .5 psi.

Replacing the Front Fairing

1. First, reconnect the heater cable (**Figure 3.1.11**).

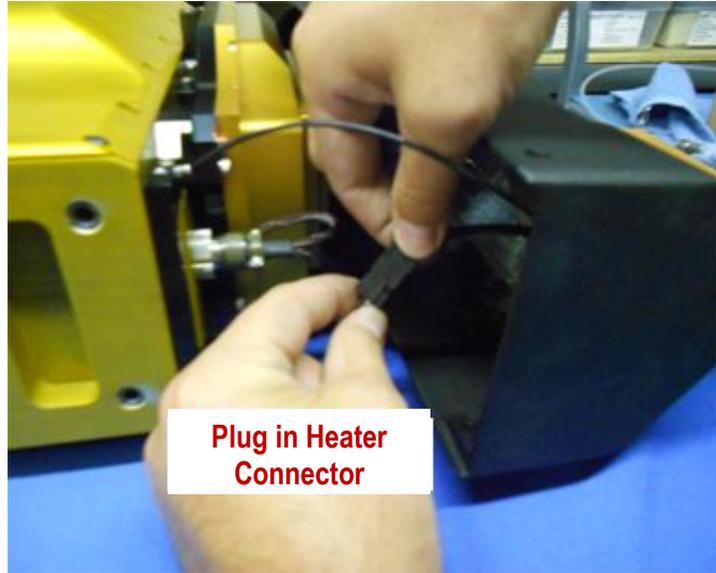


Figure 3.1.11. Reconnect the heater connector.

2. After the heater connector is plugged in, reattach the grounding wire (disconnected in **Figure 3.1.8**).

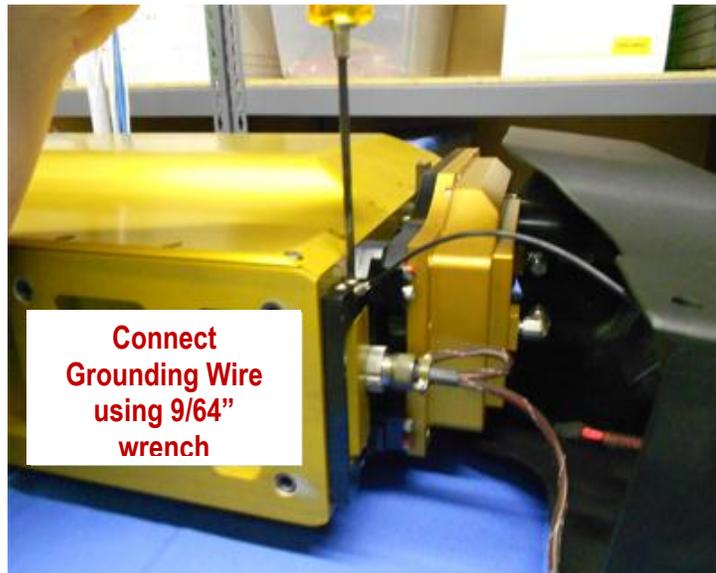


Figure 3.1.12. Reconnect the grounding wire.

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3. Next, slowly slide the fairing onto the pylon body, making sure to avoid the nose cone and not getting the cables caught (**Figure 3.1.13**).

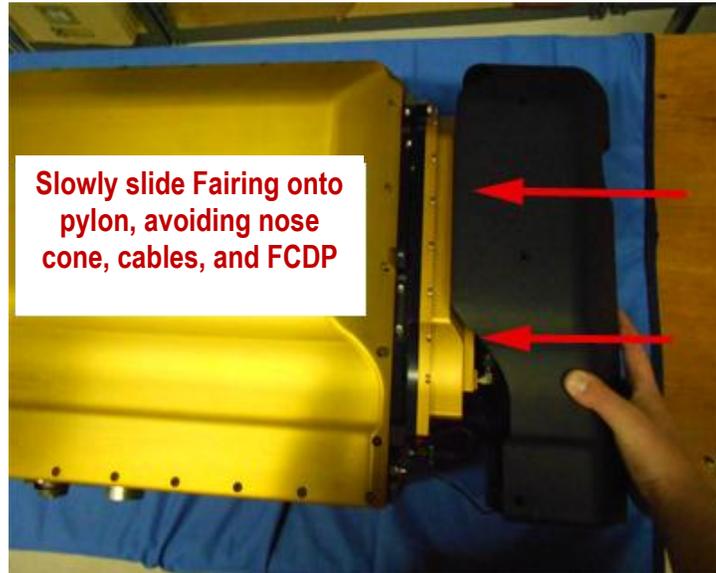


Figure 3.1.13. Carefully slide Front Fairing back onto pylon.

4. **Figure 3.1.14** again shows the locations of the 6 #8-32 front fairing fasteners. There are three on each side: the top screws on either side are 3/8", the bottom two on both sides are 5/8".

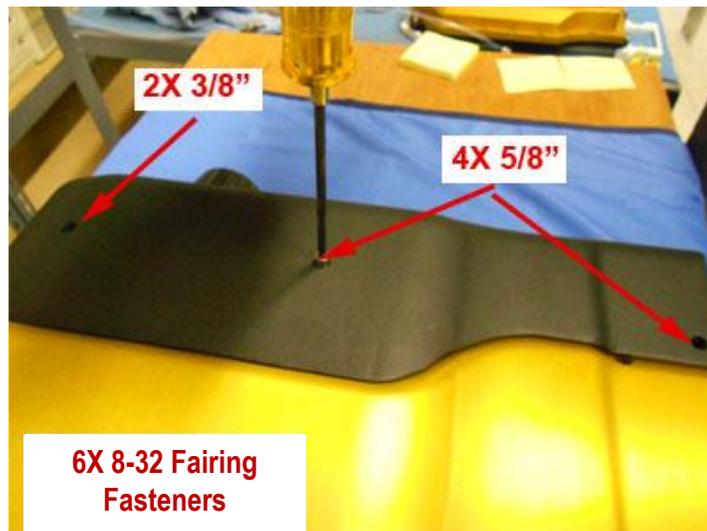


Figure 3.1.14. Placement of top 3 Fairing Fasteners (the other 3 are on the bottom side of the pylon).

5. Install all fasteners using a 9/16" Allen wrench. **Do not over tighten, as this may break the hermetic seal.**

3.2 Cleaning Hawkeye Optical Windows

During normal airborne operation, the optical windows of the Hawkeye will become contaminated due to cloud drops and streaming water. Contamination on the windows of the imaging system can result in a decreased image mean and a severely contaminated background over time. Contamination of the stereo particle windows of the 2D-S will cause false firing of the imaging system and false readings for the stereo channels. If the elemental voltages for a 2D-S channel or the FCDP are below the factory settings, the windows should be cleaned (Figure 3.2.1).

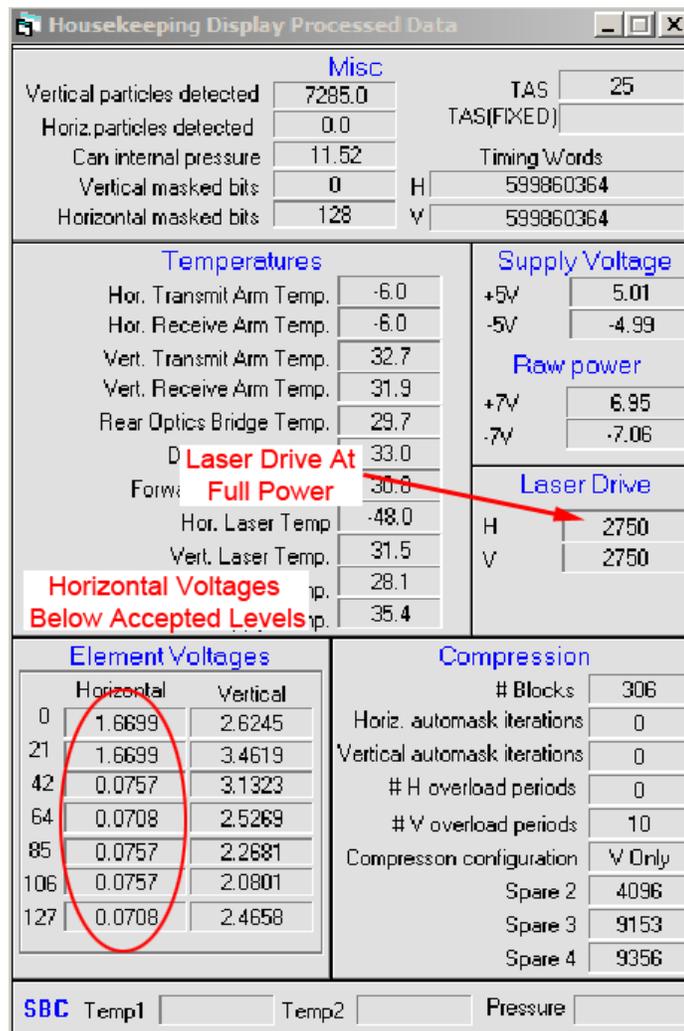


Figure 3.2.1. 2D-S Housekeeping shows low element voltages with laser drive at full power.

Items Required

- A can of electronics grade compressed air is necessary to blow off particulates
- Purified reagent grade methyl alcohol should be used as a cleaning agent because it does not leave streaks as it evaporates and will not damage the AR coatings
- 100% pure cotton swabs (lab grade). Do not use a type of cotton swab that can damage the window
- Delrin rod cleaning tool provided with the Hawkeye
- A bright light (such as an LED light) to inspect the windows



Figure 3.2.2. Items needed for cleaning the Hawkeye optical windows.

Warning! The Hawkeye optical windows are made of sapphire and coated with a high performance anti-reflective (AR) coating. The windows are bonded into the optical block using a thermally conductive epoxy. This interface serves as a hermetic seal between the internal pylon and air flowing through the sample tube. Extreme care must be taken when working around the windows. A special, non-metallic cleaning tool has been provided with the Hawkeye. **DO NOT INSERT SHARP METALLIC OBJECTS INTO THE SAMPLE TUBE THAT CAN SCRATCH THE COATED WINDOWS. ONCE THE AR COATING IS DAMAGED, REPLACING THE WINDOWS IS EXTREMELY LABOR INTENSIVE AND COSTLY.** Cleaning of the optical windows should only be performed by personnel who have read and become familiar with this procedure using only the tools and materials described in this procedure.

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Cleaning

It is recommended to read through each of the following steps before proceeding.

1. **Figure 3.2.1** showed the Housekeeping Menu in the 2D-S GUI. If the menu shows low elemental voltages with the laser drive at full power, the windows should be cleaned. Write down the array element voltages displayed in the Housekeeping Window, there are seven elements for each array. The goal in cleaning is that you are trying to raise the transmission of light, which corresponds to higher array voltages. Once the baseline voltages are recorded, the system can be turned off so as not to overheat the probe on the ground.
2. Visually inspect each window. Shine a bright LED light on each window to look for contamination. **Figure 3.2.2** shows the relative location of each of the windows in the optical block.

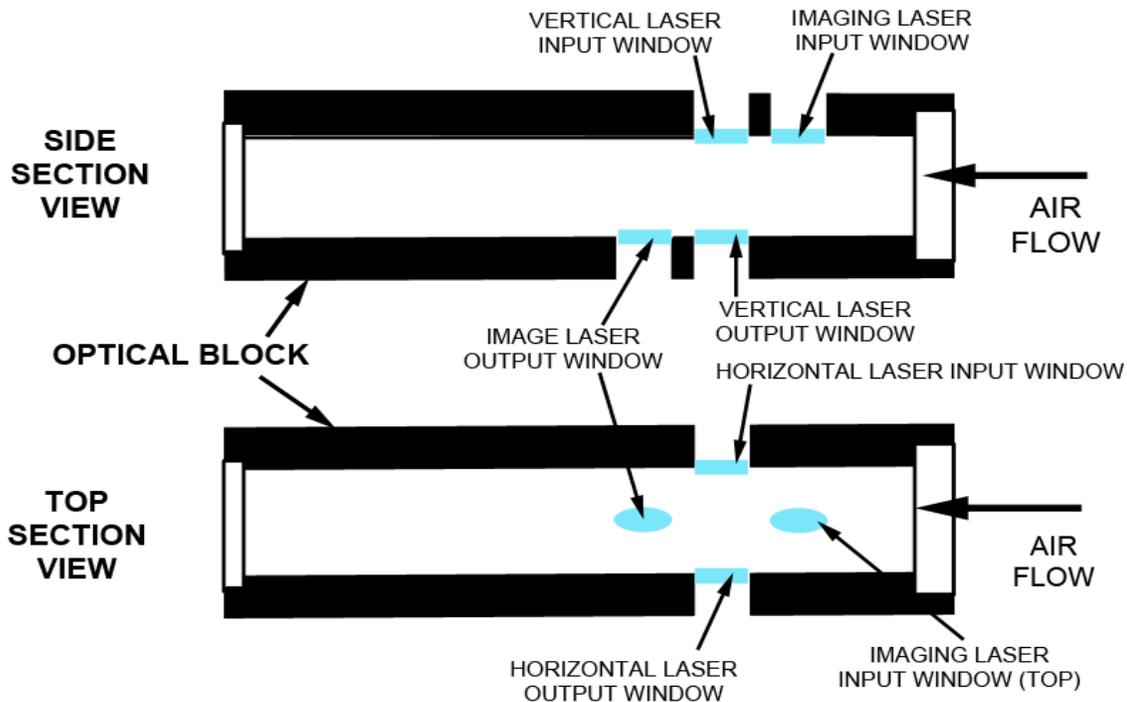


Figure 3.2.2. Cutaway of optical block showing laser beam locations and window locations.

3. Particulates pose the greatest threat to the windows because they can scratch the coatings, therefore this step is very important in order to protect the AR coating on the windows. Using a bottle of compressed air, blow the air over each of the windows to remove any particulates. The compressed can should be at a distance and intensity where no liquid refrigerant gets on the windows. Do not tip the canned air, as liquid will come out and contaminate the windows.

4. Take a cotton swab, break it in half, and insert one half into the hole at each end of the cleaning tool. Cut off the back of the swab so it is nearly flush with the Delrin rod to allow for maximum clearance (**Figure 3.2.3**).

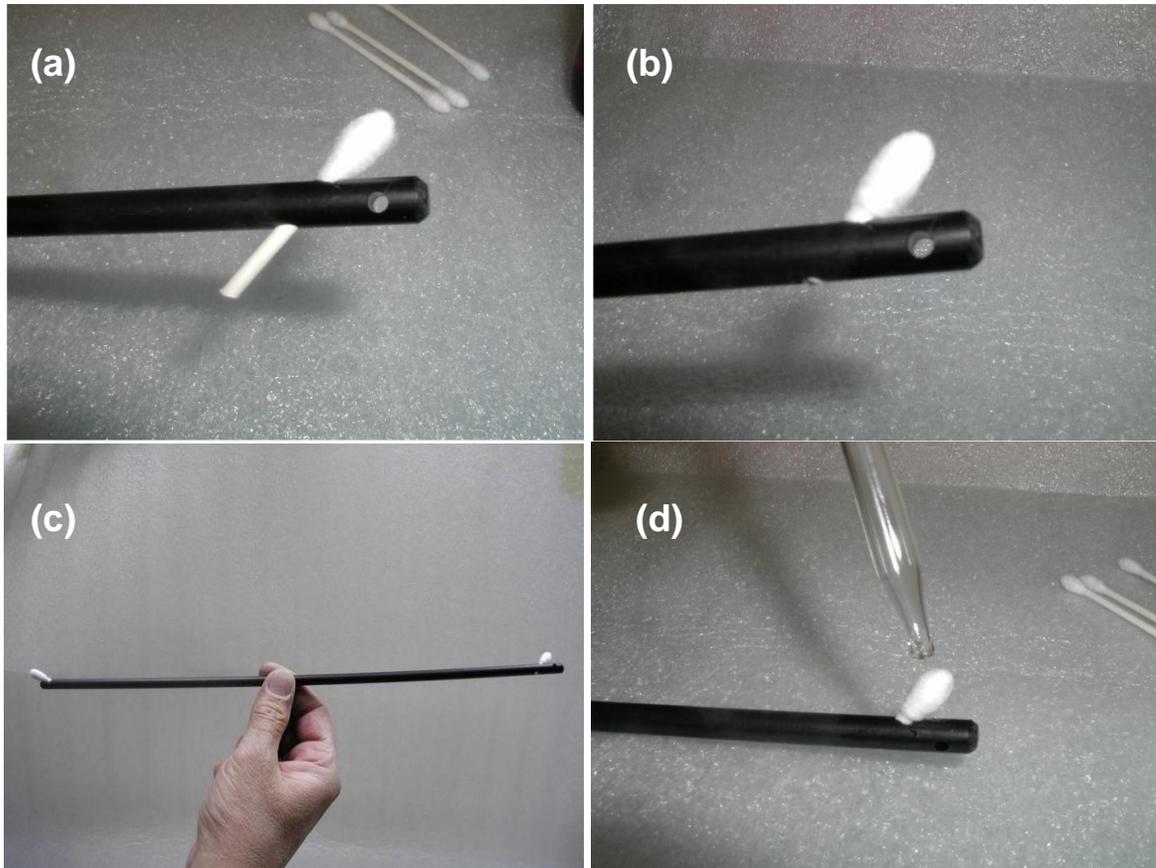


Figure 3.2.3. Proper (a) insertion and (b) sizing of cotton swab in (c) Delrin rod prior to (d) using the eyedropper to dispense one drop of methyl alcohol on swab for cleaning.

5. One complete swab will be used for each window. Using the eyedropper from the methyl alcohol, dispense one drop onto one of the half cotton swabs (**Figure 3.2.3d**). The wetted swab will first be used in a back and forth motion across the window to remove the contamination. The dry half of the swab (on the other end of the Delrin rod) will be used to remove the residual alcohol.
6. Each of the optical systems should be cleaned in order, and each window must be specifically targeted (**Figure 3.2.4**). As shown in **Figure 3.2.4a and 3.2.4b**, insert the cleaning tool with the wetted end of the swab first, clean and dry only the window you are targeting. Observe the result of the cleaning in the real time software. The cleaning tool is inserted in the direction of airflow through the probe, from the end where the nose cone mounts. For each 2D-S channel and the FCDP:

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- a. Verify the lasers are at full power. Observing the detector DC level, clean and dry the input window of the channel, and note any changes in the DC level.
 - i. If the DC level decreases slightly or stays the same, move on to the output window for the same channel.
 - ii. If the DC level increases during cleaning, that window should be cleaned again until the DC level decreases or stays the same.
- b. Repeat (a) for the other 2D-S channel (**Figure 3.2.4c**) and the FCDP (**Figure 3.2.4d**) till all three have been properly cleaned.

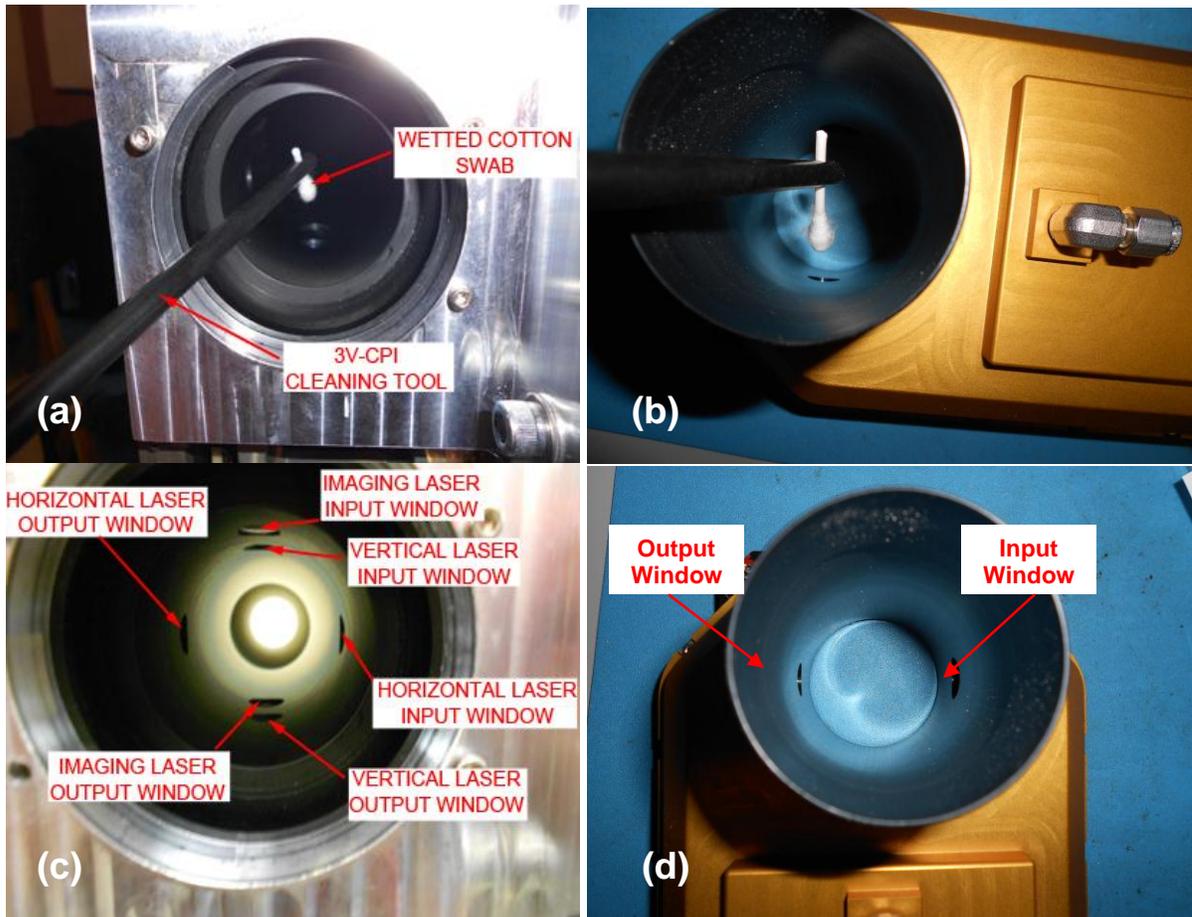


Figure 3.2.4. Proper insertion of the wetted cotton swab into (a) 3VCPI and (b) FCDP, and location of (c) 2D-S and CPI and (d) FCDP input and output windows.

7. Clean the 3VCPI imaging system windows (**Figure 3.2.4c**). Before cleaning the imaging system windows, run the probe in Live Video Mode and locate any contamination visible by the CCD array. Observe the effect of the cleaning on the CCD array image, there should be fewer contaminants visible after cleaning. Also observe the image mean in real time. The image mean should increase or stay the

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same after cleaning. If the image mean decreases or more contaminants are present in the CCD image, repeat the cleaning procedure.

Cleaning of the windows can occur when the probe is mounted to an aircraft, or in the laboratory, in or out of the pylon. The nose cone can be removed (see Pylon Cover Removal Procedure) to improve access to the optical windows. **Replace the nose cone after cleaning.**

The exact location of the windows depends on the orientation of the probe. This is critical for identifying which window is being cleaned. **Figure 3.2.4** shows the internal sensors removed from the pylon in the laboratory with the input windows on top and the output windows on the bottom. Use **Figures 3.2.2 and 3.2.4** as references to locate the windows in any orientation.

SPECIAL CLEANING NOTES:

In maritime conditions, salt residue on the windows is likely. In addition to using compressed air, use distilled water on the windows to dissolve and remove any salts from the windows prior to rubbing the windows with the Methanol.

In non-maritime cases where the windows are extremely dirty (e.g. smoke plume) you can use reagent Acetone to clean the windows. Acetone will leave a residue and must be followed by a cleaning with Methanol.

3.3 Pylon Cover Removal and Replacement

Warning! The Hawkeye pylon is a high performance assembly that serves as a protective housing for the internal sensor head components and as the structural interface to the aircraft. It is hermetically sealed up to approximately 65,000 ft altitude. O-rings and precision-machined surfaces are used to achieve this seal. **Improper disassembly/assembly of the pylon or mishandling of the components can result in damage that will compromise the pressure integrity of the pylon. This may result in malfunctioning of the instrument during flight. Disassembly/Assembly of the pylon should only be performed by personnel who have read and become familiar with this procedure.**

The Hawkeye sensor head pylon cover must be removed to gain access to the internal sensor head. This step is necessary if the internal sensor head is to be completely removed from the pylon, or to perform electronics troubleshooting of the internal sensor head while in the pylon. Removal of the front faring may be necessary to access the FCDP Pylon Heater 1 or the nose cone. The front faring may be removed with the pylon cover on or off. The photographs show the sensor head lying flat on a table. The pylon should always be placed on a soft material, such as foam, to avoid scratching the outer surface. This procedure can also be followed when the sensor head is mounted on an aircraft.

The pylon internal pressure is monitored in the Housekeeping data. If the internal pressure drops during flight, a leak in the pylon cover's seal is indicated. If the instrument was being flown in a wet environment when the pressure dropped, the pylon cover should be removed after the flight. The internal sensor should be inspected for moisture. If moisture is found, allow the pylon internal sensor to dry out before putting the pylon cover back on. **The AR coatings on the optical block windows are sensitive to high humidity environments. Do not allow moisture to reside in the closed pylon, it will damage the AR coatings.**

3.3.1 Pylon Cover Removal

1. Torx plus fasteners are used to fasten the pylon lid to the pylon body. This type of fastener uses a special type of drive to minimize stripping of the drive head over repeated use. Special T15 Torx Plus drivers (**Figure 3.3.1**) are necessary to work on the pylon. These drivers have been provided with the Hawkeye.



Figure 3.3.1. Special Torx drivers and fasteners used for Hawkeye pylon.

2. 32 black-oxide #8-32 X 1/2" Torx plus fasteners are used to fasten the pylon cover to the pylon body (**Figure 3.3.2**). It is important to not use fasteners longer than 1/2". Using longer fasteners could break through they pylon, causing it to lose all pressurization. The center fastener is #1/4-28 X 1" and requires a 3/16 Allen wrench.

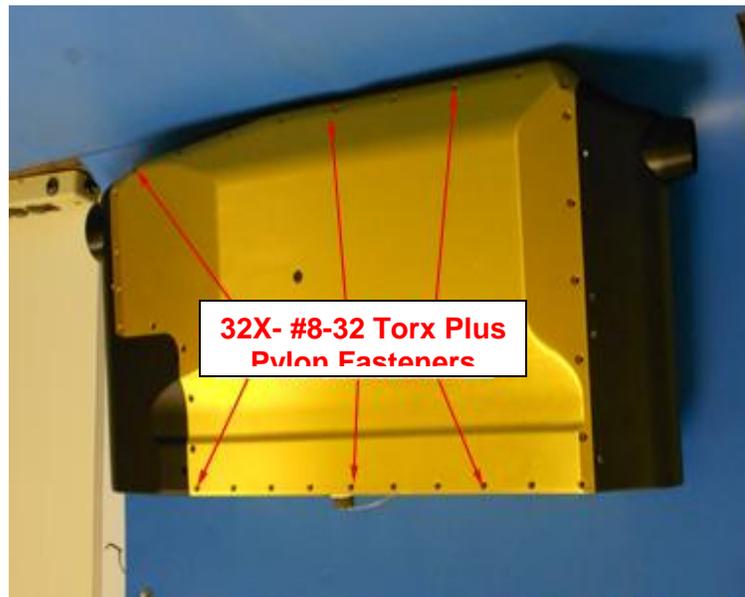


Figure 3.3.2. 8 Torx Plus fasteners connect the pylon cover to the body.

3. Using the Torx plus driver, gradually loosen all the pylon fasteners approximately 1/4 to 1/2 turn, saving the center, #1/4-28, fastener for last (**Figure 3.3.3**). This will gradually decrease the compression on the O-ring, and uniformly decrease the stress on the pylon cover. Once all the fasteners have been initially loosened, proceed to

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remove them until all 32 fasteners are removed. Place the fasteners in a safe place, as they will be reused during reassembly.

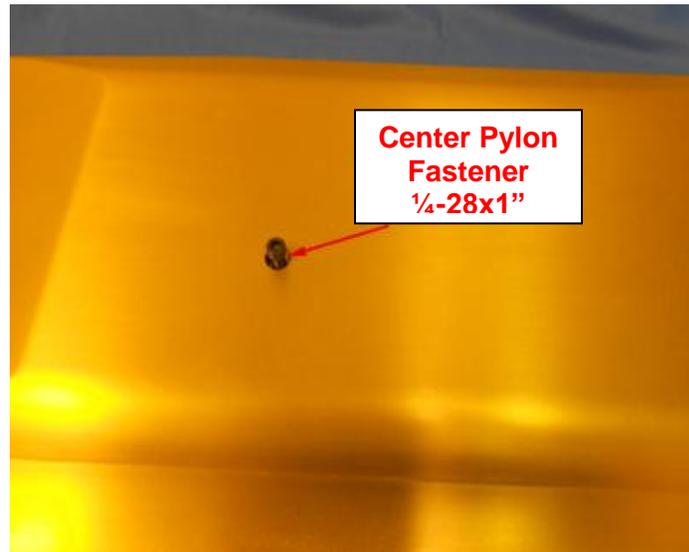


Figure 3.3.3. Center pylon fastener should be removed last.

4. Verify that all 32 fasteners and the one center fastener have been removed from the pylon cover. Using the edge of the cover, gradually lift the pylon cover upward (**Figure 3.3.4**). Take care not to damage the tongue or O-ring on the pylon cover. Very little force should be required to lift the tongue on the pylon cover from the groove on the pylon body.

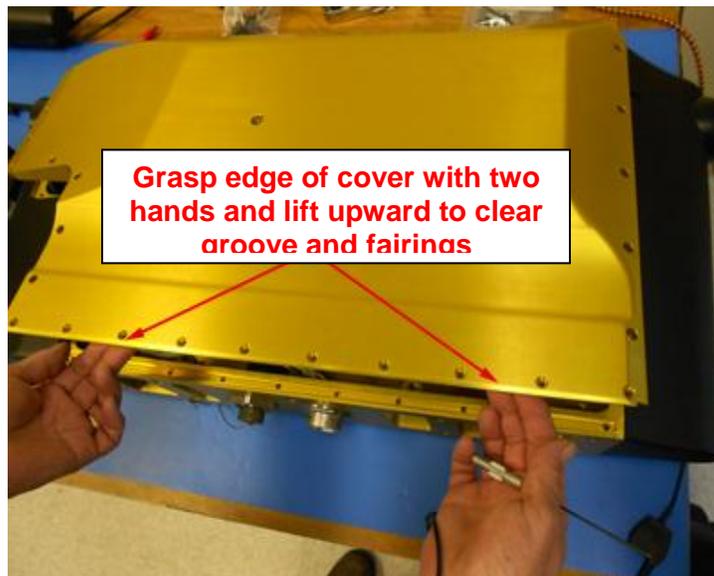


Figure 3.3.4. Gradually lift the pylon cover upward.

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5. After the cover has been freed from the groove, grasp the cover with two hands and gently lift the cover directly upward until it clears the internal sensor head assembly.
6. Place the cover in a safe location such as a static mat (**Figure 3.3.5**).



Figure 3.3.5. Place pylon cover on static mat.

7. Inspect the O-rings for wear that may occur over time. If the O-rings appear damaged, they should be replaced (**Figure 3.3.6** shows locations of the O-rings, and the parts of the pylon cover and body that mate together).

3.3.2 Pylon Cover Replacement

The Hawkeye sensor head pylon cover must be installed for airborne operation of the Hawkeye sensor head. The following photographs show the sensor head lying flat on a table. The pylon should always be placed on a soft material, such as foam, to avoid scratching the outer surface. The following procedure should also be used when the sensor head is mounted on an aircraft.

CAUTION: *The Hawkeye pylon is a high performance assembly that serves as a protective housing for the internal sensor head components and as the structural interface to the aircraft. It is hermetically sealed up to approximately 65,000 ft altitude. O-rings and precision-machined surfaces are used to achieve this seal. Improper disassembly/assembly of the pylon or mishandling of the components can result in damage that will compromise the pressure integrity of the pylon. This may result in malfunctioning of the instrument during flight. Disassembly/Assembly of the pylon should only be performed by personnel who have read and become familiar with this procedure.*

1. Verify Hawkeye sensor head power is turned off.
2. **Figure 3.3.6** shows the important areas of the pylon cover that must be aligned during installation of the pylon cover.

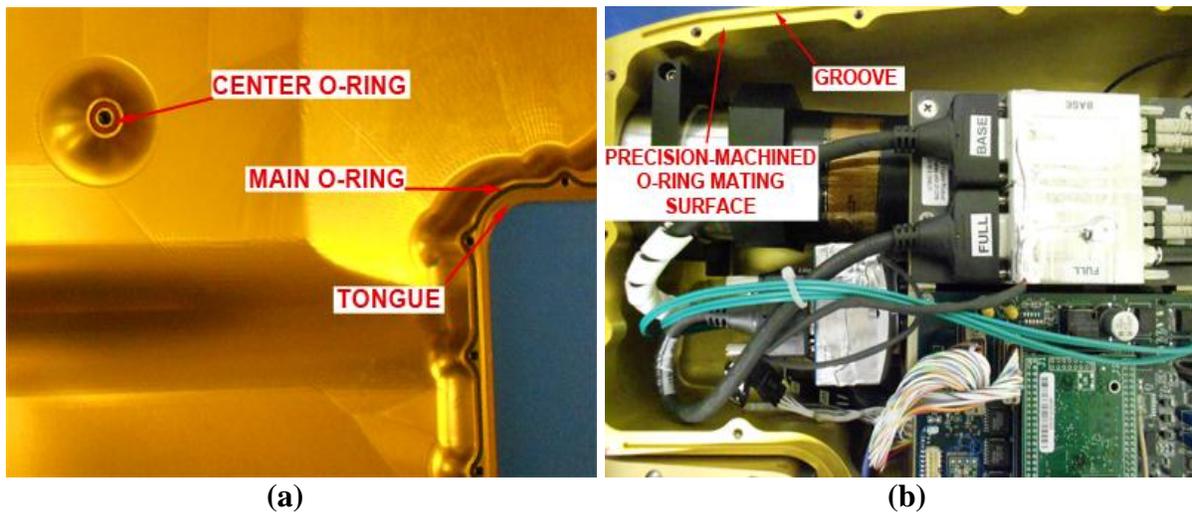


Figure 3.3.6. Locations of O-ring, tongue, and groove for mating of pylon cover and body.

3. Hold the pylon cover and gradually lower onto the pylon body so the tongue and groove and pylon connector are aligned as shown in **Figures 3.3.6** and **3.3.7**. The O-ring must be fit inside the groove all the way around, or a proper seal will not be achievable.

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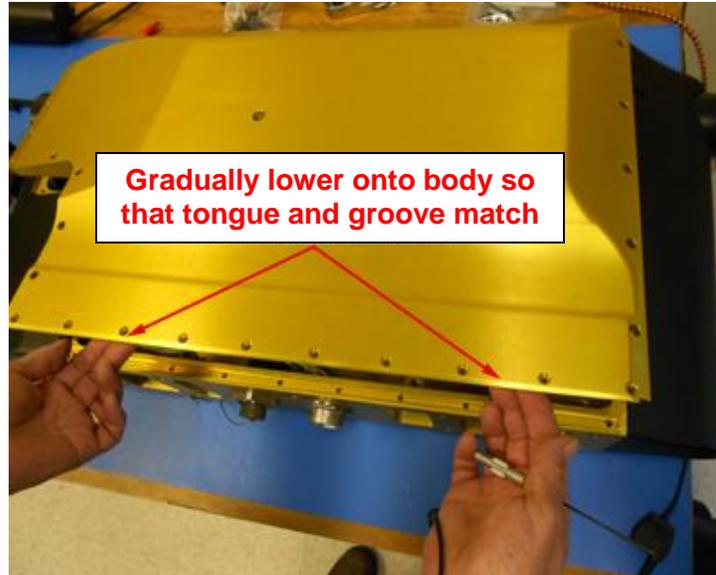


Figure 3.3.7. Gradually lower pylon cover, ensuring that the O-ring is within the groove, and the groove lines up with the tongue.

4. Gently lower the pylon cover into the position shown. If the pylon cover is not properly aligned, it will not be flush with the pylon body.
5. Using a 3/16 Allen wrench, install the center pylon fastener, but **do not tighten it down completely (Figure 3.3.8)**. It may be necessary to push the pylon cover down by hand slightly to maintain alignment of the tongue and groove while the center fastener is being tightened.

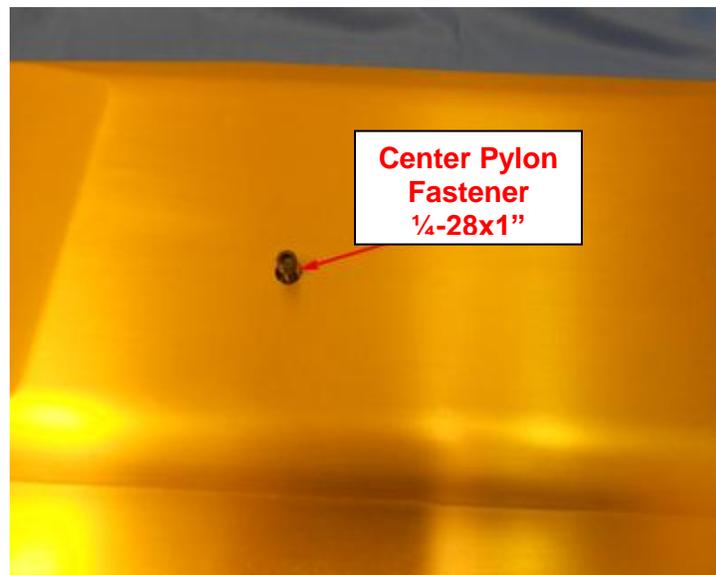


Figure 3.3.8. Location of center fastener on pylon.

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6. 32 black-oxide #8-32 X 1/2" Torx plus fasteners are used to fasten the pylon cover to the pylon body. Install the 32 fasteners in the proper locations using the T15 torx plus driver, engage all the fasteners but **do not tighten completely**. As the various fasteners are engaged, verify the pylon cover remains aligned to the pylon body (**Figure 3.3.9**).

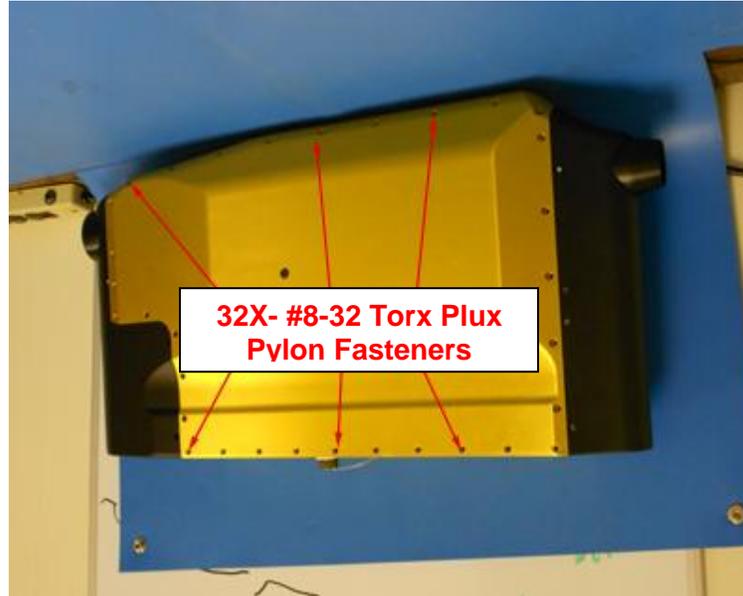
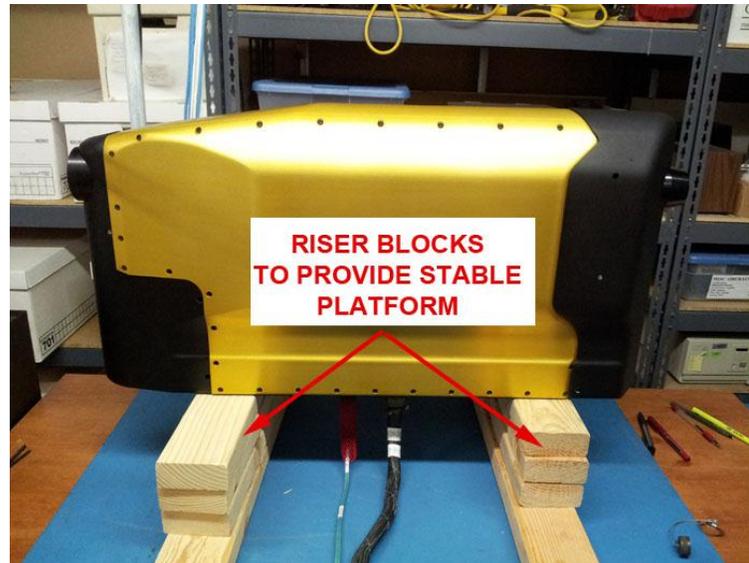


Figure 3.3.9. 8 Torx Plus fasteners connect the pylon cover to the body.

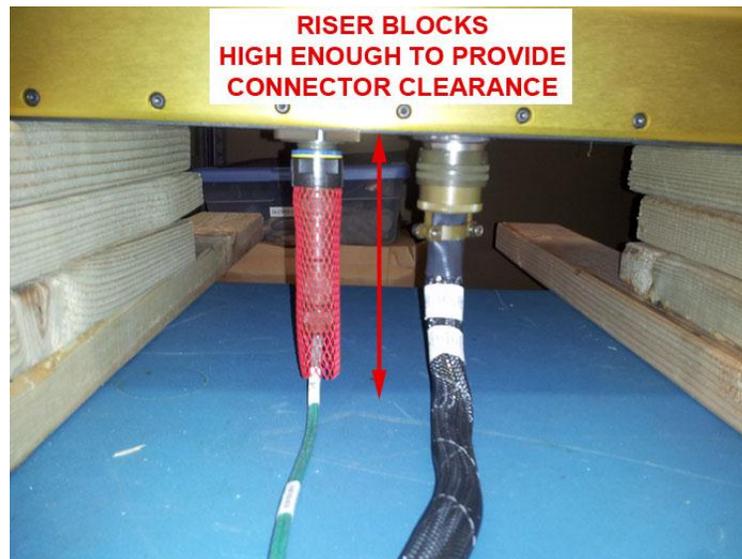
7. After all the pylon fasteners have been engaged, begin the process of completely tightening each of the fasteners. The gap between the pylon cover and body will be completely closed as the cover is tightened down. **Do not use excessive force on the fasteners as they may break or puncture the hermetic seal of the pylon body.** It will be obvious when the fasteners are completely tight because they will be much harder to turn.
8. **Verify all fasteners are completely tightened.** The ones initially tightened may require additional tightening after all fasteners are completely installed.

3.4 Atomizer Setup for Laboratory Testing

1. Verify that the Hawkeye has been connected to the Data Acquisition System (DAS) unit following the connection procedure in **Section 2.2**.
2. Place the Hawkeye on stable riser blocks (**Figure 3.4.1**). Height of the blocks should be sufficient to provide clearance for the bottom connector (**Figure 3.4.1b**), but low enough to keep the instrument stable (**Figure 3.4.1a**).



(a)



(b)

Figure 3.4.1. (a) Placement of Hawkeye on stable riser blocks in order to keep the instrument stable, but (b) provide enough clearance for the connectors.

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3. Plug in the Vacuum Hose Adapter Rear Insert into the Hawkeye exhaust tube, and the Front Insert into the Hawkeye inflow tube. The Front and Rear Inserts are shown in **Figure 3.4.3**, with the correct installation of the rear insert in **Figure 3.4.4a**, and the front insert in **Figure 3.4.4b**.



Figure 3.4.3. Hawkeye Front and Rear Inserts for atomizer setup.

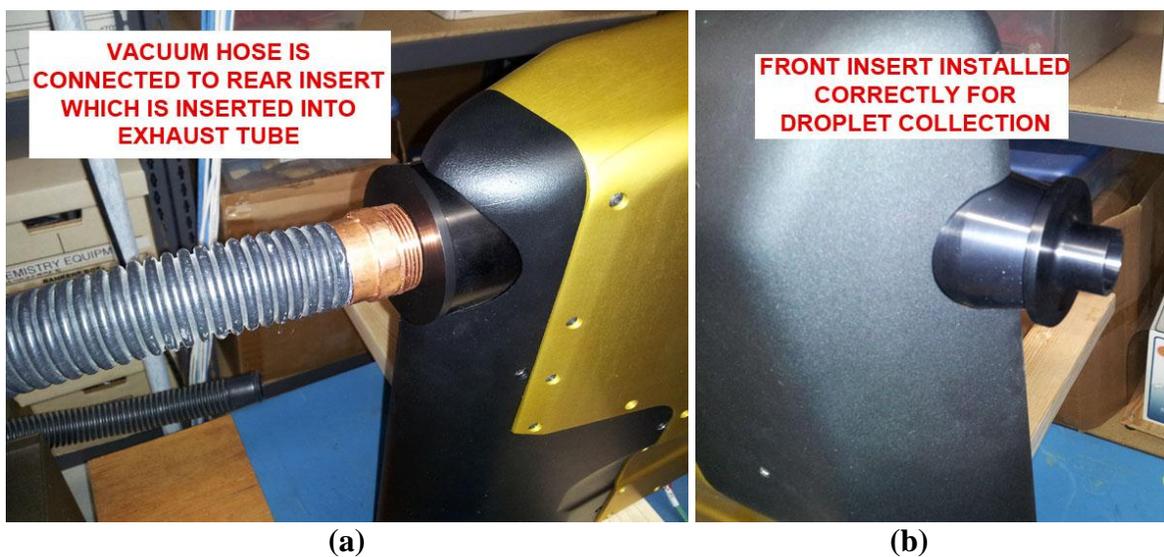


Figure 3.4.4. Proper placement of (a) Rear Insert and vacuum hose and (a) Front Insert.

4. Spray the droplet atomizer across the front inflow of the Hawkeye (**Figure 3.4.6**). The atomizer should spray drops in a direction perpendicular to the direction of airflow into the Hawkeye. **DO NOT** spray drops directly into Hawkeye along flow direction. Water drops will contaminate the windows and the windows will need to be cleaned.

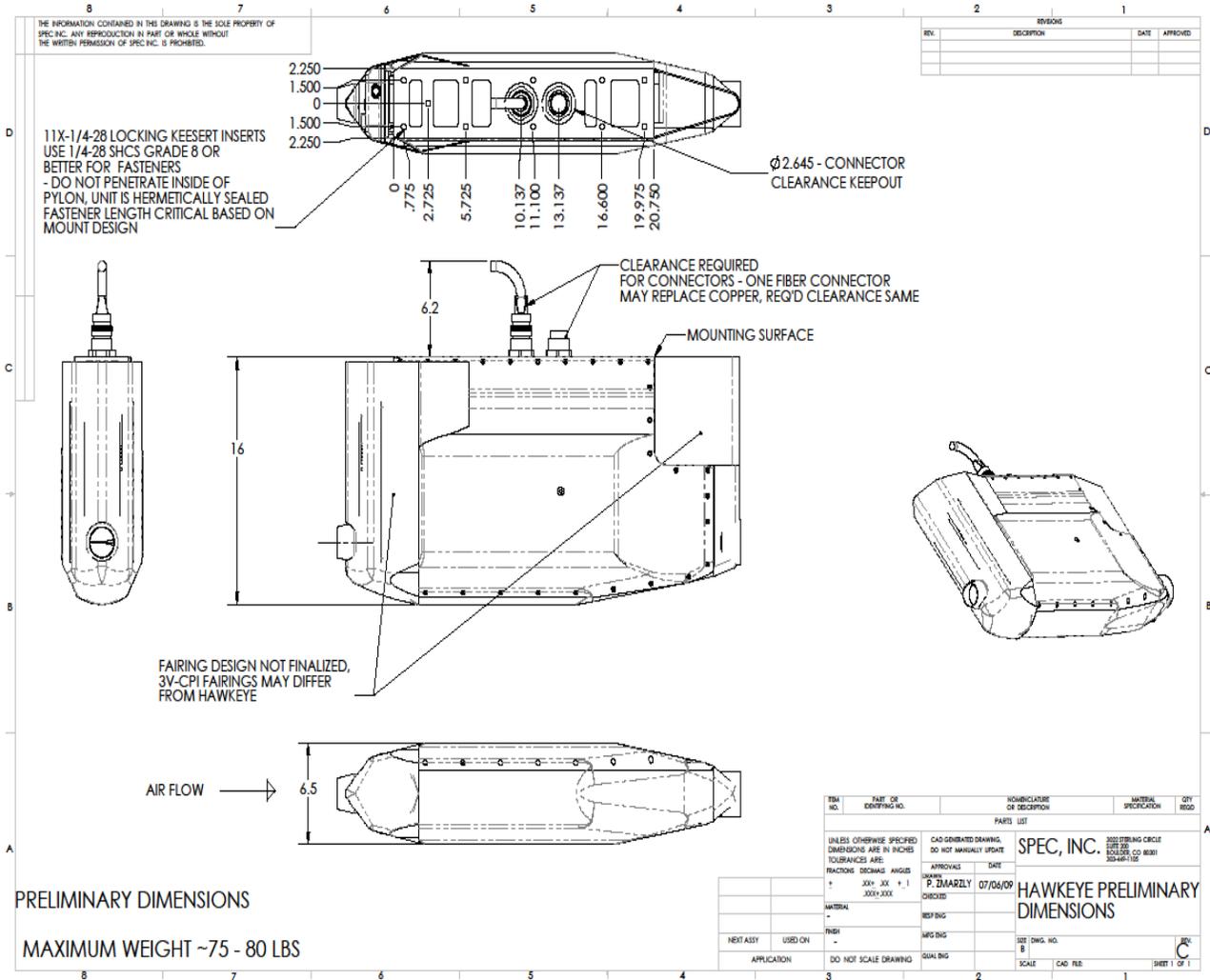


Figure 3.4.6. Spray droplet atomizer across Hawkeye inflow, perpendicular to direction of airflow into the instrument.

5. Power on the data system and probe per the Hawkeye startup procedure, **Section 2.3**, and run both the CPI and 2D-S GUIs.
6. After the programs have successfully started and obtained a background, turn on the vacuum cleaner and spray water drops by squeezing the atomizer bulb. Both GUIs should show water drops appearing in real time. Note: if the vacuum is turned on before the Hawkeye has obtained a background, it may take longer for the Hawkeye to obtain a background due to particles passing through the sample volume.

Appendix A

Attachment Footprint



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