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14. ABSTRACT
During this reporting period the first set of experiments were conducted successfully. In February, near-field and far-field acoustic measurements were made simultaneously for all jet conditions of interest. In April, the team was successful in integrating the MHz PIV system and performing synchronous data collection with the near-field and far-field acoustics. The April experiments also produced multi-exposure pulse-trace PIV images that may lead to a useful data analysis method for future use. CFD simulations are nearing completion and will shortly be ready for comparison to measurements.

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TOWARD ACTIVE CONTROL OF NOISE
FROM HOT SUPERSONIC JETS

Quarterly Progress Report No. 3

1 FEB 2012 – 30 APR 2012

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Executive Summary

During this reporting period the first set of experiments were conducted successfully. In February, near-field and far-field acoustic measurements were made simultaneously for all jet conditions of interest. In April, the team was successful in integrating the MHz PIV system and performing synchronous data collection with the near-field and far-field acoustics. The April experiments also produced multi-exposure pulse-trace PIV images that may lead to a useful data analysis method for future use. CFD simulations are nearing completion and will shortly be ready for comparison to measurements.

May 14, 2012

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1 Project Objectives and Status

1.1 Objectives Overview

The primary objective for this program is to acquire high-fidelity, time-resolved, synchronous flow-field and acoustic data on a laboratory scale, hot, supersonic, shock-containing jet. The planned experimental campaign includes three nozzle configurations,

- round, conical, converging-diverging (C-D) nozzle,
- round, conical, C-D nozzle with upstream centerbody, and
- faceted C-D nozzle,

each of which will be operated at perfectly expanded ($M_j = 1.74$) and over-expanded ($M_j = 1.55$) conditions at a nominal total temperature of 1350°F. CFD analysis will yield comparative data on these same 6 configurations.

1.2 Status of Current and Completed Task Items

The task items for the 'base' program are listed in Table 1 showing the designated team lead and the completion percentage as of the end of the reporting period. The bulk of the work in the past quarter was on WBS 1.0 and 2.0 and in particular the completion of the first synchronous experiment incorporating the MHz rate PIV system with the acoustic measurements. More detail on the current work is presented in Section 2.

The major accomplishment during this reporting period was the successful completion of the first joint synchronous experiment utilizing the systems from each of the academic team members. CRAFT Tech personnel also played an important role in carrying out the experiments.

2 Activity for Current Reporting Period

The work during the past report period included two major experimental efforts:

1. February 2012 – Test Entry 2: Near-Field/Far-Field Acoustics
2. April 2012 – Test Entry 4: Simultaneous PIV & Near-Field/Far-Field Acoustics

Test Entry 1 (Single-Point Measurements of the Mean Flow) was completed earlier and was discussed in the previous quarterly report. Test Entry 3 involved acquiring diagnostic PIV images using a standard 2-component setup to check flow seeding levels in preparation for the MHz rate PIV experiments. Test Entry 5 was conducted in tandem with Test Entry 4, and it involved the use of a PCO.Edge camera to acquire flow visualization images with the Pulse-Burst Laser system.

The bulk of the effort by all team members during the past reporting period was expended on supporting the first major experimental efforts outlined above. For Test Entry 2, U.T. Austin traveled to NCPA and completed the setup and installation of the near-field array in the Anechoic Jet Laboratory (AJL). For Test Entry 4 & 5, Auburn U. successfully

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WBS	Task	Resource	% Complete
	Main Idea		21
1	Develop Analysis Methodologies and Plan Experiments		71
1.1	Identify Existing LES Data for a Hot Supersonic Jet	CRAFT Tech	100
1.2	Design Near Field Array	UT Austin	100
1.3	Evaluate Expected Jet Velocity Characteristics for PIV Measurements	Auburn	100
1.4	Develop Computation of Space-Time Velocity Correlations	U. Miss NCPA	10
2	Perform Experiments and Computations of a Hot Supersonic Jet		65
2.1	Obtain Single-Point Measurements of Hot, Supersonic Jet Exhaust	Academics	70
2.2	Obtain Synchronous Data for Hot, Supersonic Jets	Adademics	50
2.2.1	Synchronous Experiment 1 - Year 1		100
2.2.2	Synchronous Experiment 2 - Year 2		0
2.3	Perform LES Computations of Experimental Conditions	CRAFT Tech	75
3	Analyze and Reduce Experimental Data		10
3.1	Reduce and Analyze PIV Data	Auburn Lead	0.0
3.2	Analyze Near-Field and Far-Field Data	UT Austin Lead	15
3.3	Determine Experimental Uncertainty	U. Miss NCPA Lead	10
3.4	Compute Space-Time Correlations in the Near-Nozzle Region	U. Miss Lead	15
4	Compare Experimental and Computational Results	All	5
5	Acquire Additional Experimental Data (As Needed)	N/A	0.0
6	Establish Computational Phased-Array Methodology	CRAFT Tech	50.0
7	Form Conclusions about the Effect of Nozzle Configuration on Noise	All	0.0
8	Prepare Quarterly Reports	U. Miss NCPA Lead	40
8.1	Q-01 Report		100.0
8.2	Q-02 Report		100
8.3	Q-03 Report		100
8.4	Q-04 Report		0.0
8.5	Q-05 Report		0.0
8.6	Q-06 Report		0.0
8.7	Q-07 Report		0.0
8.8	Q-08 Report		0.0
9	Prepare Final Report	U. Miss NCPA Lead	0.0

Table 1. WBS Listing for Base Program with designated lead team member and completion percentage.

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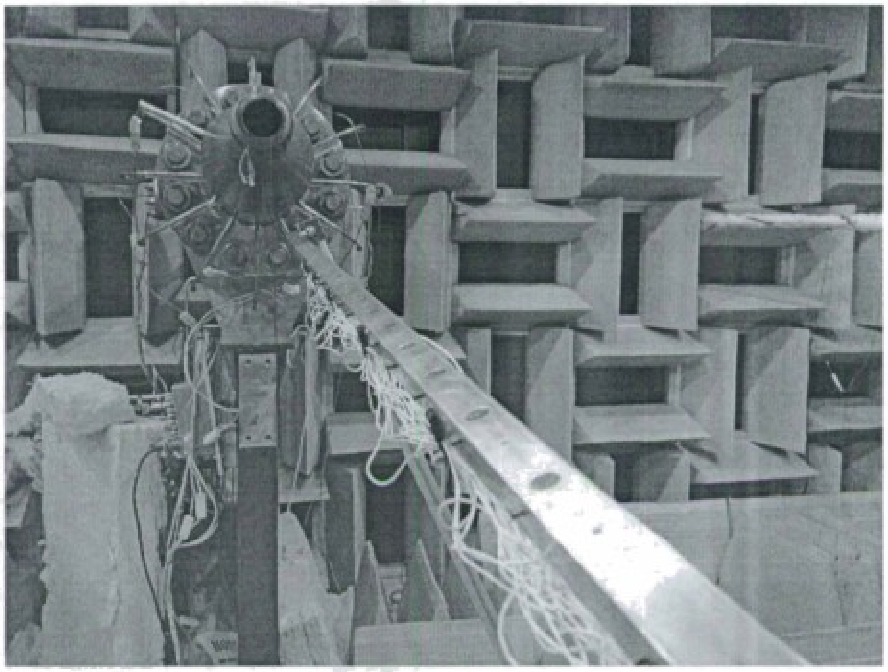

Figure 1. Photo of the near-field line array positioned in the AJL for the Feb. 2012 experiments.

deployed their MHz rate PIV system in the AJL. Test Entry 4/5 was conducted in April 2012 with NCPA, Auburn U., and CRAFT Tech participation. Further details of these efforts are discussed below.

2.1 Acoustics Experiment – February 2012

In February 2012, U.T. Austin participated in a joint experiment with NCPA to acquire acoustic data for all the planned nozzle configurations. The U.T. Austin graduate student, Brian Donald, was in residence at the NCPA for the duration of this effort to support setup and operation of the near-field array. The graduate students from Auburn U., Harris Haynes, and U. Miss., Gregory Lyons, were also present and active in carrying out the work. The experiments were directed by the graduate students under direction from NCPA and CRAFT Tech researchers (Drs. Murray and Panickar). Other NCPA personnel acted in support of facility operation and setup (B. Jansen, M. Joachim, M. Panickar).

Figure 1 shows the near-field line array installed in the AJL. The array was positioned such that the microphone locations corresponded as closely as possible to layout planned based on CFD predictions of the jet plume devlopment (see Figure 13 in Quarterly Report No. 2). The larger holes in the array arm provide a mounting location for larger microphone holders for 1/4-inch PCB microphones. For the February experiments, these holes were covered with aluminum tape and only the Kulite sensors were used for data acquisition. Figure 2 is a close up of the array showing in detail the Kulite sensors which have an integral grid cap.

During the February experiment, data was collected on the near-field array synchronously with far-field microphone data. Figure 3 illustrates the position of the microphones relative

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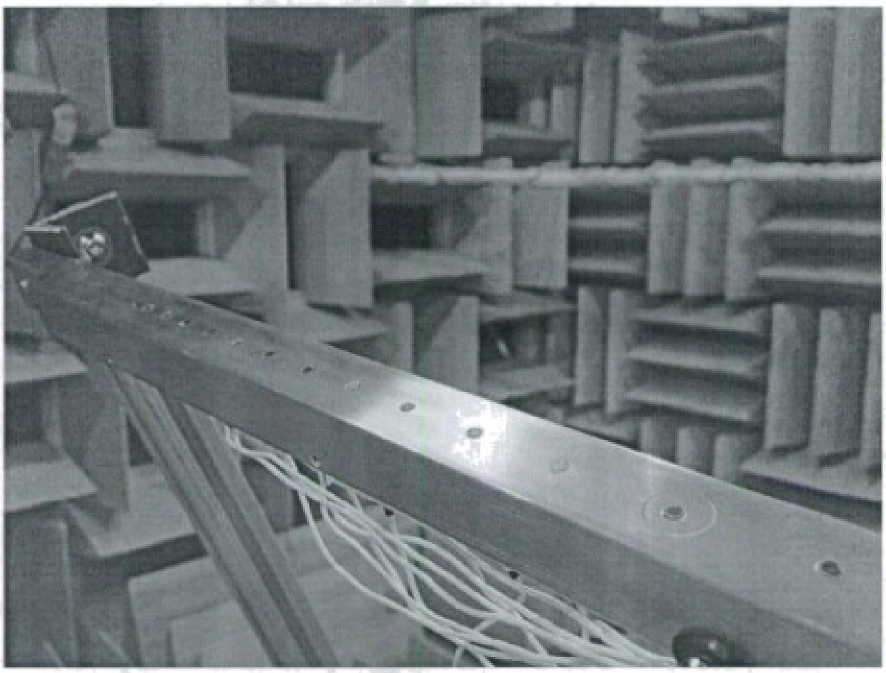

Figure 2. Close up of near-field array showing the Kulite transducers.

to the jet nozzle. Two synchronization methods were tested for later implementation with the PIV system: (a) the systems were initiated manually and aligned in post-proeessing and (b) the systems were triggered automatieally by the same input from a NI Labview DataSocket eonnection. It was determined that the DataSocket initiation did not perform as desired, so only the data reeorded manually was able to be synchronized. To enable synehronization, both systems recorded the same TTL output from a Stanford DG535 timing box that was caused to output a single-shot pulse. The reeorded pulse could them be aligned manually during post proeessing. Figure 4 shows an illustration of the post-proeessing applied to one of the data sets. The mierophone data shown in the figure is the *same* physieal microphone recorded on both systems to provide a cheek on the synchronization.

Following the completion of the experiment, a data archival format was developed that would allow for easy data sharing among the research teams. This format includes the aeoustie data along with all ealibration, data acquisition, and setup information and also includes all the jet conditions for a given aequisition. All this information is bundled into a single Matlab file. Matlab was ehosen beeause the variable names are retained in the file making the result as self-definable file format. Figure 5 shows the variables imported when the files is opened in Matlab. Other users are not restrieted to Matlab as there are Fortran and C libraries available from Mathworks for reading the file format.

Currently, the U.T. Austin group is working on arehiving the near-field data. They are also heading up the analysis of the February aeoustic data as a whole. Preliminary results are being generated for a conference paper to be presented at the INTERNOISE 2012 eonference.

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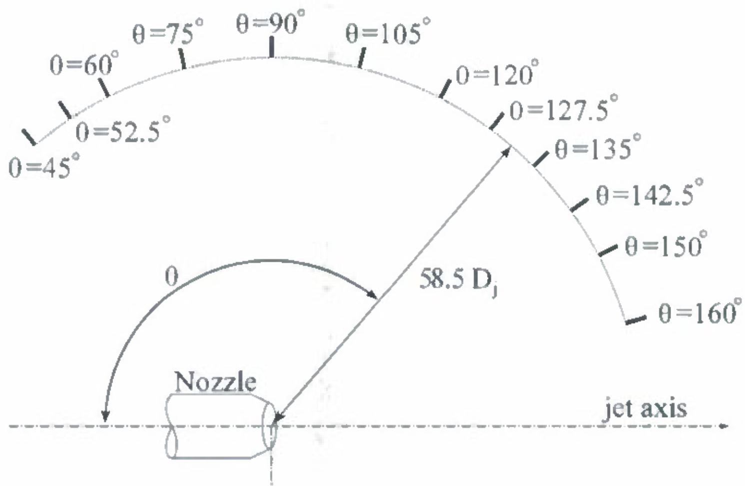

Figure 3. Illustration of the far-field microphone locations in the NCPA AJL.

2.2 Synchronous Experiment – April 2012

In April 2012, all data acquisition systems were implemented together for an experiment which allowed for synchronous acquisition of the near-field and far-field acoustics with the MHz rate PIV measurements of the jet flow. Graduate students from U. Miss. and Auburn U. were instrumental in completing the experiment under the direction of their advisors. CRAFT Tech personnel also played a significant role in setting up the synchronization of all the data acquisition systems. Figure 6 shows G. Lyons and H. Haynes setting up the far-field array and the Cordin PIV camera for the experiment.

Figure 7 shows the AJL as it was setup for the April 2012 experiments. The Pulse Burst Laser for the MHz PIV system was located outside of the anechoic chamber and directed into the chamber through beam steering optics. The small optics stand in the bottom/center of the photo shows the light sheet forming optics that generated a planar light sheet in the vertical centerplane of the jet. As shown in the photo, care was taken to maintain the "anechoic" nature of the room as much as possible by integrating the supports for the near-field array and light sheet optics into the wedge floor. Unfortunately, the large size of the Cordin camera was unavoidable, but the camera and tri-pod were covered with acoustic foam as best as possible.

Figure 8 shows a photo of the AJL during data acquisition. A pulse burst from the Pulse Burst Laser (PBL) is illuminating the room. The nozzle can be seen glowing red due to high temperature operation. Even after continuous operation for over 1 hour at full jet temperature, the temperature measured at the camera never exceeded 108 °F.

2.2.1 Details of Data Acquisition and Synchronization for April Experiment

Dynamic pressure data for the April experiment were acquired using the two microphone arrays described above.Digitized fluctuating pressure data from the respective arrays were independently recorded and stored on two separate National Instruments PXIe (PCI eXtensions for Instrumentation-express) systems. The NCPA PXIe system uses a PXIe-4497 card

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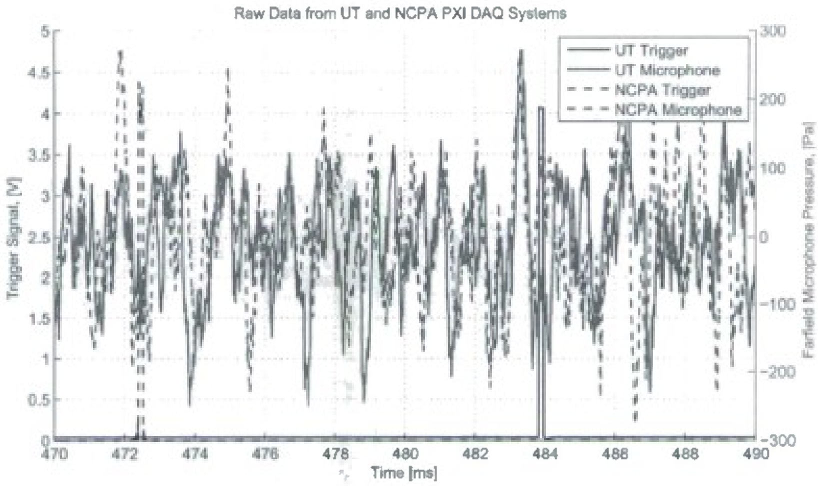
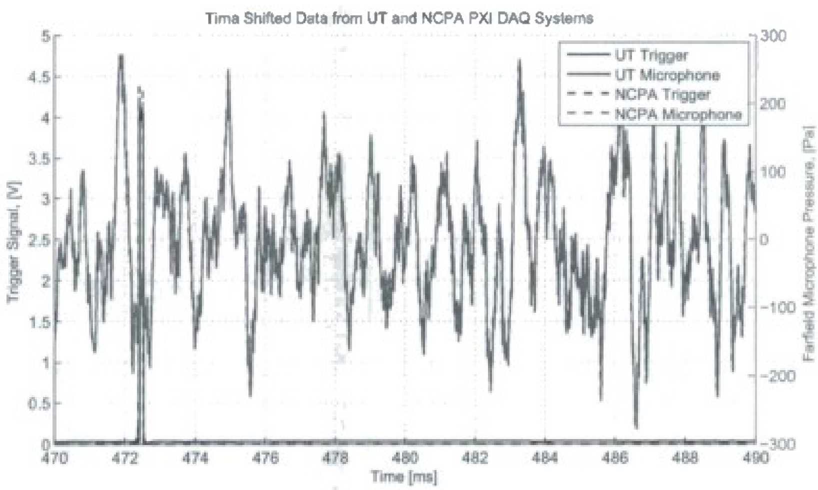


(a) Prior to Post-Processing Alignment



(b) After to Post-Processing Alignment

Figure 4. Time traces showing the method of time shifting the data during post processing to synchronize the near-field and far-field signals.

Name ▲	Value	Class
HowToCovertVoltageToPascals	'Pressure_Pa = (10^(124...	char
JetParameters	<1x1 struct>	struct
MicrophoneCalibration_RMS_V	<1x12 double>	double
MicrophoneData_V	<524288x12 double>	double
NozzleExpansion	<1x1 struct>	struct
NumberOfSamples	<1x1 struct>	struct
RunDescription	<1x1 struct>	struct
RunInformation	<1x1 struct>	struct

Figure 5. Variables in the far-field data archival Matlab file format.

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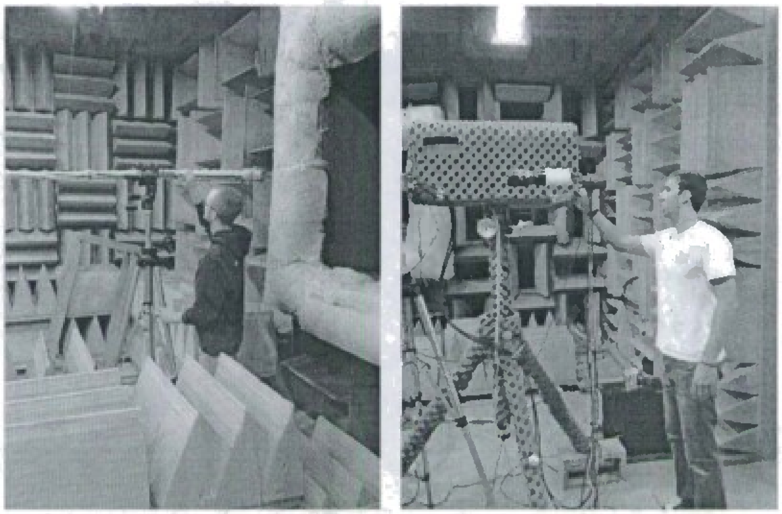

(a) Far-Field Array Calibration (b) MHz Rate PIV Camera Setup

Figure 6. Graduate student setting the various system components for the April 2012 experiment.

Figure 7. The NCPA Anechoic Jet Laboratory setup with all data acquisition systems ready for the experiment. Annotations designate the contributions from each team member to the experimental setup.

Figure 8. Photo of the AJL illuminated by a PBL pulse burst during data acquisition in the April 2012 experiments. The nozzle can been seem glowing red due to the high temperature operation.

(16 analog input channels, 24 bits of resolution, 204.8 kHz maximum sample rate). This card also has a digital trigger connector that can be used to start data acquisition upon receipt of an external TTL signal. The U.T. Austin (UTA) PXIe system has four PXIe-4331 cards(8 channels, 24 bits of resolution, 102.4 kHz maximum sample rate) and 1 PXIe-6341 card (16 bits of resolution, 500 kHz maximum sample rate). The latter card was interfaced using a BNC-2110 shielded connector box (16 analog input/output channels, 14 programmable function input (PFI) channels). In order to acquire dynamic data on the UTA system, the PXIe-6341 card was designated as the master device and the PXIe-4331 cards were designated as slave devices. An external TTL signal could be input into one of the PFI channels on the master device which trigged the data acquisition on both master and slave devices simultaneously.

In order to validate the synchronization, the external trigger signal was recorded on both PXIe systems in addition to the unsteady pressure signals. Also, the signal from the $\theta = 160°$ farfield microphone was send to both the NCPA and UTA system. This allows, during postprocessing, precise alignment of the data acquired by both PXIe systems using the common trigger and farfield microphone signals (as discussed above and shown in Figure 4).

Dynamic data was acquired at 100 kHz on both PXIe systems. Since the Cordin camera's image download time was long, it was only able to acquire an image sequence every 10-12 seconds. Rather than recording all the acoustic data continuous and saving very large data sets, the auxiliary output from the camera was used to automatically trigger the acoustic data acquisitions. For each image sequence the acoustic data systems acquired 50000 pre-trigger samples and 100000 post-trigger samples, bringing the total data acquisition time for a single data acquisition event to 1.5 seconds. Figure 9 shows a schematic view of the synchronized data acquisition process implemented using LabVIEW Virtual Instrument programs.

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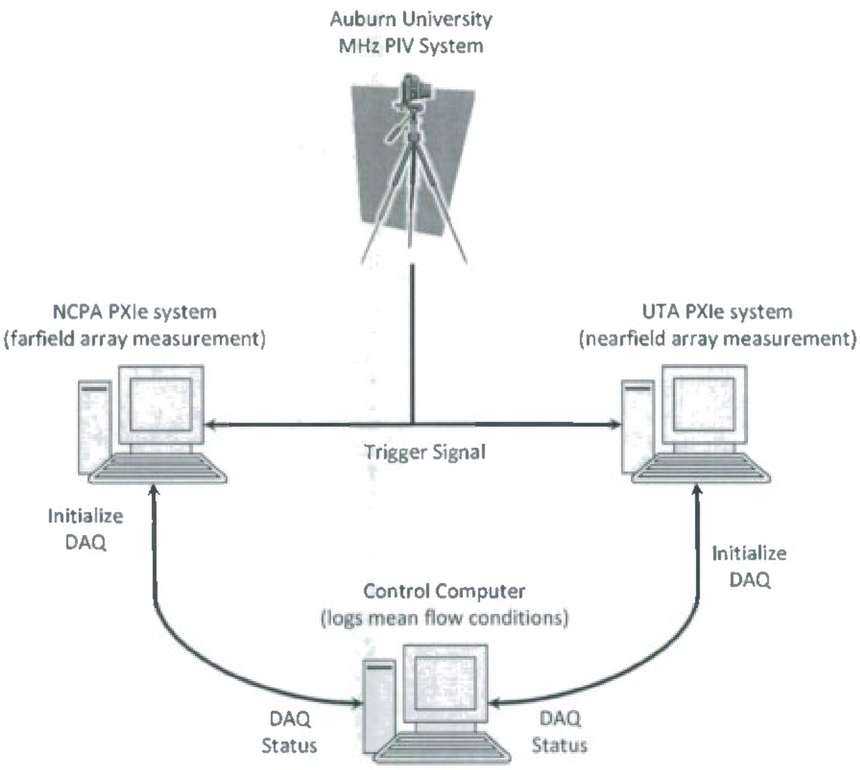

Figure 9. Schematic of the synchronized data acquisition between the nearfield and farfield microphone arrays and the PIV system.

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A hands-off procedure for obtaining the synchronized data was established to allow the PIV camera (the slowest element in the acquisition system) to control all the other elements:

1. the jet is started up and brought to predetermined setpoint conditions of pressure and temperature and allowed to run continuously,

2. the control computer initializes the UTA and NCPA PXIe systems setting the DAQ parameters (channel lists, sample rate, number of samples and analog input voltage range) on both PXIe systems and generating a filename for the acquired data,

3. the filenames for the data stored on each PXIe system are appended with the same auto-incrementing event number that is provided to it by the control computer which makes it convenient to identify the same event numbers on each data acquisition unit,

4. after initialization, the systems are set in a mode wherein they wait for a TTL trigger to start acquiring dynamic data from the nearfield and farfield arrays,

5. the TTL signal is obtained from the camera of Auburn University's MHz PIV system, and

6. both PXIe systems acquire and save dynamic data on their respective computers.

Items 5 and 6 are repeated continuously until the desired number of acquisitions have been completed. The status of each PXIe system during data acquisition (waiting to initialize, waiting for trigger, acquiring data, writing data, finished writing) is communicated to the control computer. This bi-directional communication between the control computer and both PXIe computers was accomplished using LabVIEW datasockets.

To provide a check on the near-field synchronization with the far-field microphones, a simple balloon pop was used. Figure 10 is a photo giving a reference for the location of the balloon during this check. The balloon was held near the nozzle exit and the resulting signals provided positive verification that the synchronization was working.

2.2.2 Summary of Experience Gained from April 2012 Experiment

The April 2012 experiment marked the first implementation of the Cordin 222-4G camera that Auburn U. acquired for use in the MHz rate PIV measurements. The overall goal of acquiring a large data set for each nozzle configuration proved to be out of reach this early in the program. However, the April experiment yielded success in some areas and uncovered the limitations that need to be addressed over the coming months to enable a second experimental effort during Year 2.

The experiments successfully demonstrated several key capabilities:

- very long run times at constant, high-temperature jet conditions,
- accurate synchronization between PIV and acoustic data,
- reliable operation of the Pulse Burst Laser system in the NCPA AJL,
- light sheet formation with minimal intrusion into the anechoic features of the AJL.

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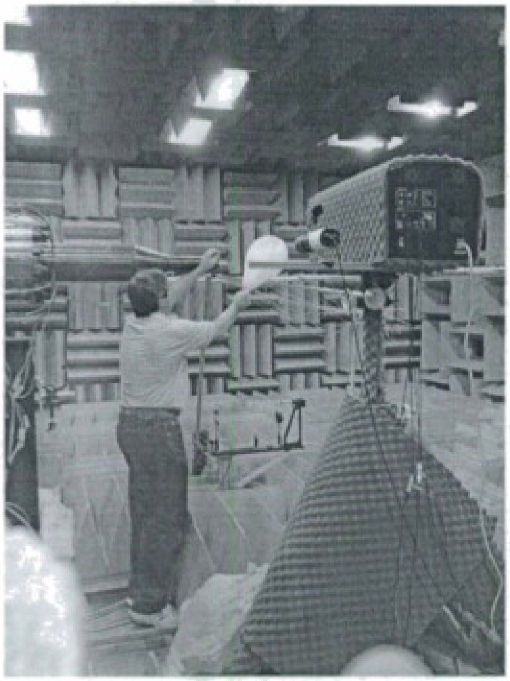

Figure 10. B. Jansen ready to conduct a balloon pop to provide a check on acoustic acquisition synchronization.

The two main limitations of the system revolve around the seeding system and the camera operation. For the April 2012 experiments, a dry air fluidized bed seeder with $0.3\,\mu m$ alumina power was used to seed the main jet flow. Compared to the current best practice (a pH-Stabilized system as pioneered by M. Wernet), this air seeder is known to be problematic. It is very likely that seed particles agglomerate in the piping between the seeder and the jet rig. It is also very difficult to maintain a consistent seed density in the flow field. To improve the seeding of the flow, a new pH-Stabilized system will be pursued.

The camera, as a newly developed system, presented its own limitations. The camera system consists of 8 separate imaging units packaged into a common housing. It was found that the camera was significantly limited by software/data-transfer issues. First, the time required for downloading an image sequence from the camera to the control computer limited the acquisition rate to 1 16-frame acquisition every 10-12 seconds. This limits the available acquisition to approximately 350 image sets in an hour of continuous run time. This presents a cost-prohibitive problem as the cost for propane fuel to enable data acquisition on all jet configurations is more than was anticipated in the original budget. Second, it was found that the data transfer of images to the computer would quite often fail resulting in partial or empty data sets. This problem occurred so frequently that it required the better part of two days of run time to acquire 500 "full" acquisitions (having 16 images). Even then, it was found that with the "full" acquisitions, the images would often be blank or rotated in a non-deterministic fashion. Auburn U. has taken these issues up with Cordin and anticipates being able to significantly improve the PIV data acquisition prior to Year 2 testing.

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Given the image acquisition limitations, the choice was made to focus on acquiring as much PIV data as possible on a single jet configuration rather than obtain a small data set for each configuration. As such, all the data acquired during the April experiment was for the conic C-D nozzle with the centerbody installed and operated at the overexpanded NPR.

The only other limitation that was identified was the power per pulse for the PBL system. In diagnostic testing of the seeding system with the U. Miss. PCO.Edge cameras, a 120 mJ/pulse New Wave Gimini Nd:YAG laser was used for illumination, and the seeding level looked sufficient. In contrast, the Auburn PBL system only produces approximately 40 mJ/pulse. This power per pulse can be adjusted, but the system was set to produce 60 pulses such that the average power per pulse would be more consistent. Reducing the number of pulses does increase the power per pulse, but it also causes the variation in power pulse-to-pulse to increase. Auburn U. will be working on optimizing the PBL setup to generate the highest power per pulse for future tests.

2.2.3 Flow Visualization with the Pulse Burst Laser

Through the course of setting up the experiment, diagnostic images of the flow illuminated by the pulse-burst laser system were recorded using a PCO.Edge sCMOS camera. These flow visualization images were found to reveal interesting characteristics and may provided a novel diagnostic. Figure 11 shows a sample image as recorded for the conic nozzle with centerbody operated at the overexpanded, 1350 °F, conditions. Distinct vortical structures of relatively large size can be clearly identified in the shear layer. The image was centered near the end of the potential core.

Because the PBL was used for illumination, the high speed particles appear in the image as dotted streaks. In regions of the flow where the individual dots can be resolved, it is possible to determine the direction, velocity, *and* acceleration along the streak. As an example of a potential image processing method, Figure 12 shows a single interrogation area extracted from the flow near the centerline of the jet. A simple auto-correlation of the sample region reveals multiple peaks as shown in Figure 12(c). The angle of the dotted line in the auto-correlation gives direction. The spacing between dots in the auto-correlation gives velocity magnitude when taken together with the time between pulses. Also, if a change in the distance between dots were evident, it may be possible to measure acceleration.

A sequence of 103 images was acquired with accompanying acoustics using the PCO.Edge and the PBL as described here. Effort will be put into determining the usefulness of this approach. It may be possible to employ a Plenoptic camera is a similar setup to determine 3-D motion of the flow using a thick light sheet.

2.3 Update on CFD Progress

In the previous interim report, results were shown that used stand-alone RANS calculations of the nozzle in order to dial in a steady profile as an inlet boundary condition for the LES and noise predictions. This lowers the fidelity of the simulation since any detailed unsteady physics which can occur in the nozzle boundary layer (bleed, film cooling, etc) are lost. In order to overcome this shortcoming, it was decided to apply a hybrid RANS-LES (HRLES) technique.The primary advantage of using HRLES is that the internal geometry of the nozzle

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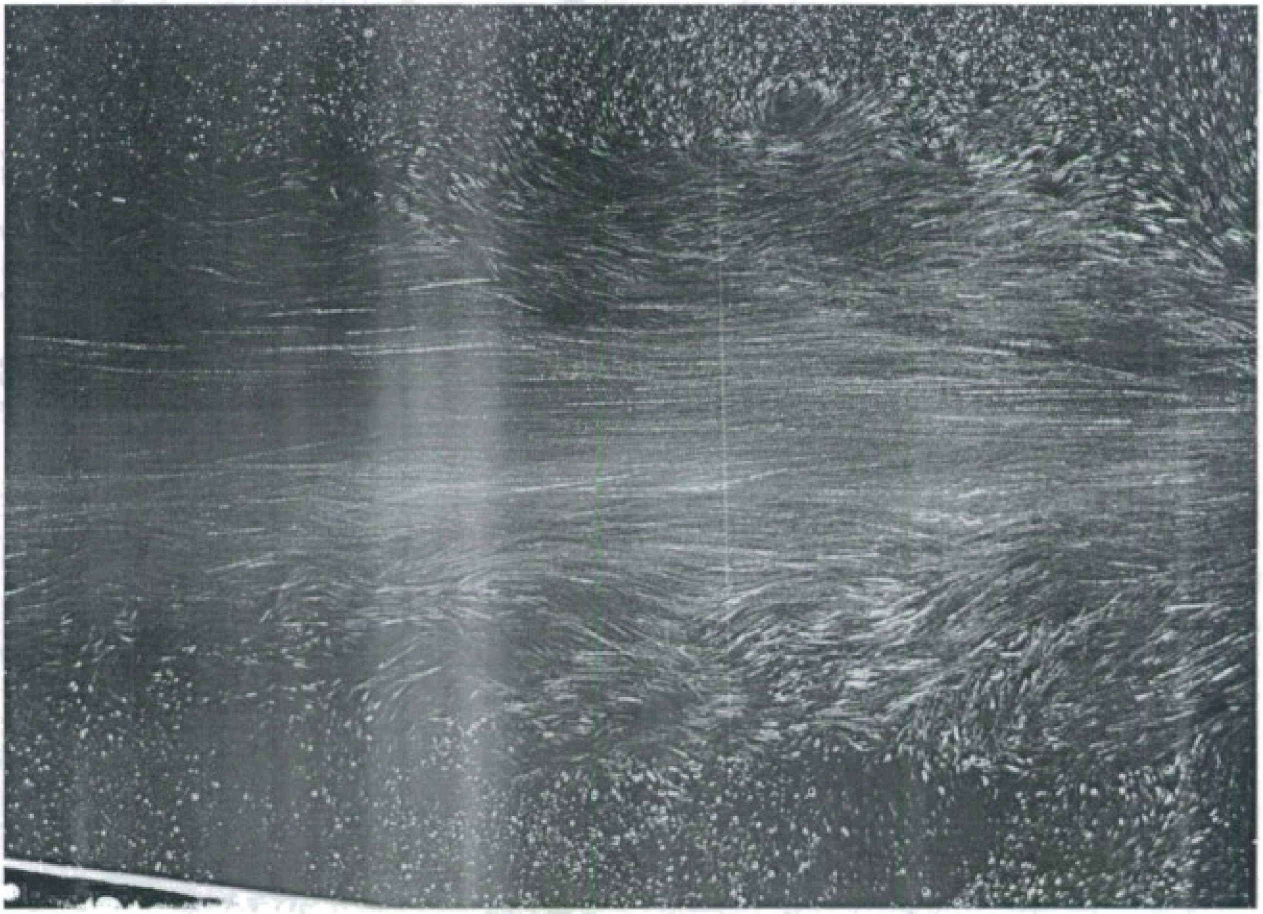

Figure 11. Single image recorded with a PCO.Edge sCMOS camera mutiply exposed by the pulse-bust laser system. Individual laser pulses are resolved as dotted streaks in the high-speed region of the flow.

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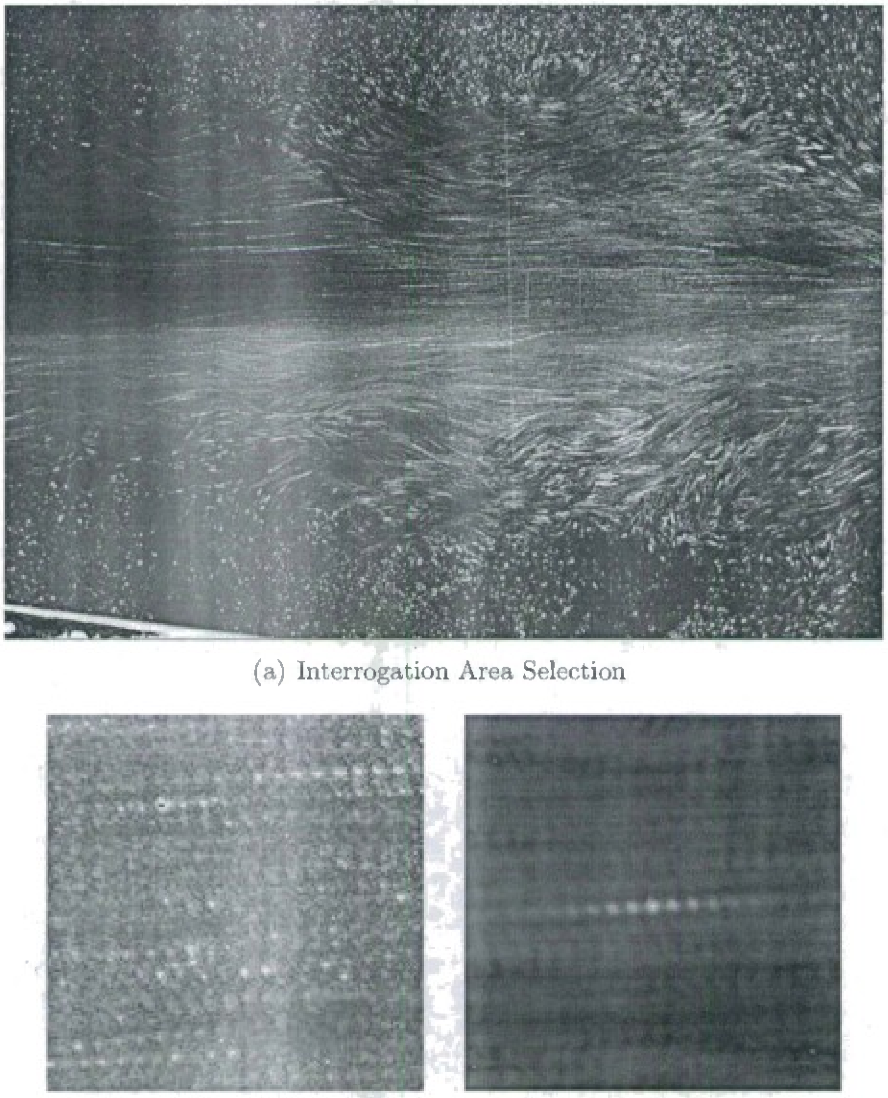

(a) Interrogation Area Selection

(b) 128-by-128 Pixel Sample Region

(c) Auto-Correlation Result

Figure 12. Illustration of potential analysis method for multiply exposed particle images.

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is included in the jet noise simulations. Including the internal geometryprovides for a smooth transition to the subgrid eddy viscosity from within the nozzle boundary layer to the LES. From a strictly flow physics point of view, HRLES simulations show faster breakdown of the shear layer past the nozzle exit. This leads to the creation of smaller scale structures that are a significant contributor to overall noise levels in the sideline and upstream directions. In contrast, the downstream direction isgoverned primarily by turbulent mixing which is captured with sufficient accuracy by the traditional LES method. For contoured nozzles, this switch from LES to HRLES may not be a necessity; however, for nozzles that contain sharp geometrical features or internal shocks likely to lead to flow separation in the nozzle it is critical to employ to CFD method that can capture these characteristics. Thus, the hope is that by using HRLES, the noise predictions in the sideline and upstream directions can be improved and show better agreement with that seen in experiments.

As reported in interim report II, approval for access to the NAVY high performance computing (HPC) resources was obtained. However, due to the amount of time taken in various account verification and approval procedures, final login access to the supercomputing clusters was not obtained until April 18th. Currently, the HRLES CRAFT code has been compiled and tested on the HPCs satisfactorily, and CFD results will be generated at a much faster rate in the future. To date,mean and fluctuating flow data for the conic nozzle configuration with the centerbody operating at correctly expanded conditions have been obtained. Figure 13 shows the mean streamwise velocity, pressure and temperature in the XZ (streamwise-vertical) plane.

The presence of the centerbody introduces a wake that can be clearly seen downstream of the centerbody inside the nozzle. The shock generated at the sharp throat is clearly visible and it's extent outside of the jet can also be seen. Additionally, the shock generated at the nozzle exit and the propagation of these two shock trains within the jet column can also be seen in these figures. Figure 14 shows the fluctuating component of the streamwise velocity at various distances downstream of the jet.

As expected, as long as the potential core persists, most of fluctuating velocity is concentrated in the shear layer and there is very little fluctuation within the core. Figure 15 shows the decay of the streamwise velocity along the axial direction for the conic nozzle configuration with the centerbody.

2.3.1 Future CFD Work

Future work on the LES modeling will involve finishing up HRLES calculations on the remaining configurations. Time resolved data recorded on an acoustic data surface (ADS) during each CFD run will then be used to estimate the farfield noise using the Ffowcs-Williams and Hawkings (FWH) method. The mean and fluctuating flowfields as well as the farfield noise, obtained from experimental measurements as well as CFD calculations, will then be compared. The FWH method will also be used to obtain estimates of time resolved pressure data at locations corresponding to those in a phased array system of microphones. This will allow us to estimate the location of noise sources in the various jet configurations.

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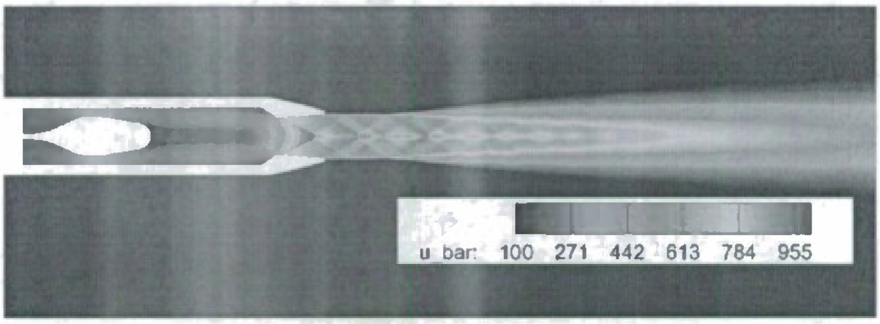
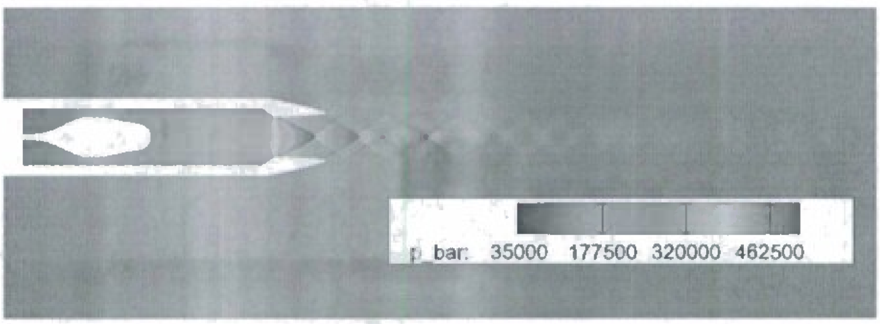
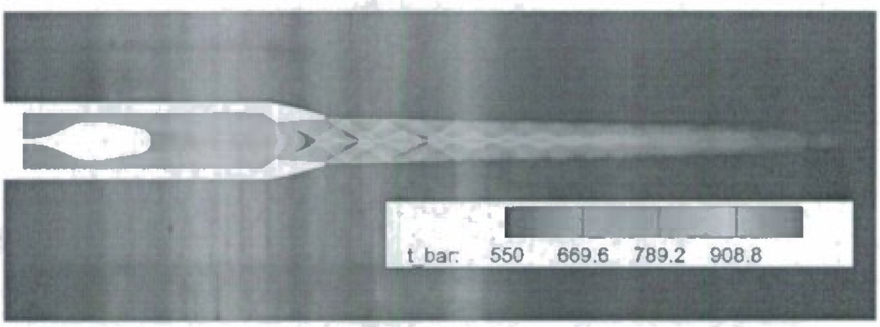


(a) Streamwise Velocity



(b) Pressure



(c) Temperature

Figure 13. Mean streamwise velocity, pressure and temperature contours in the streamwise-vertical (XZ) plane for the conic nozzle with the centerbody.

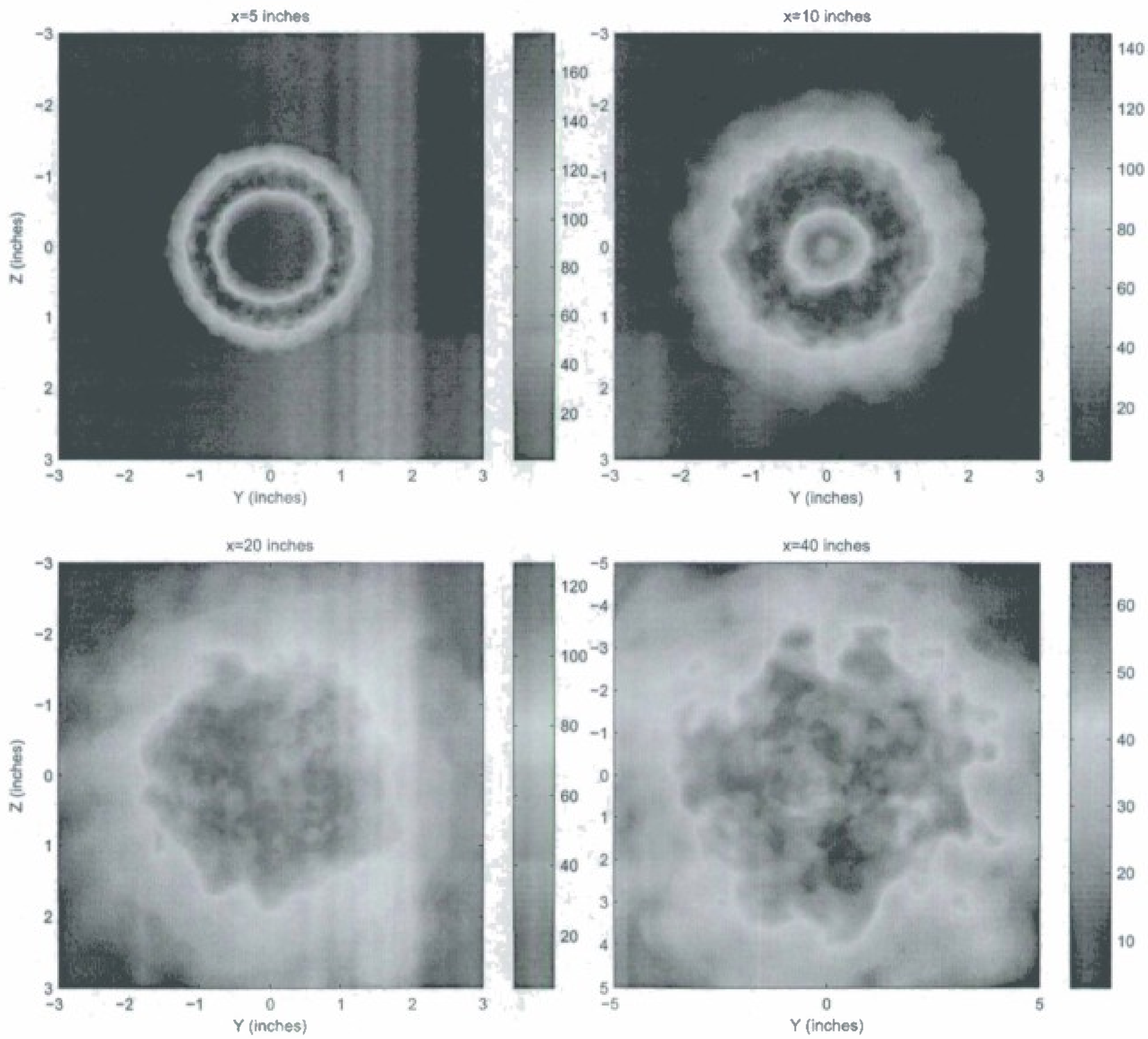


Figure 14. Contours of the fluctuating component of the streamwise velocity in the YZ (cross-) plane at constant axial stations computed by HRLES for the conic nozzle with the centerbody.

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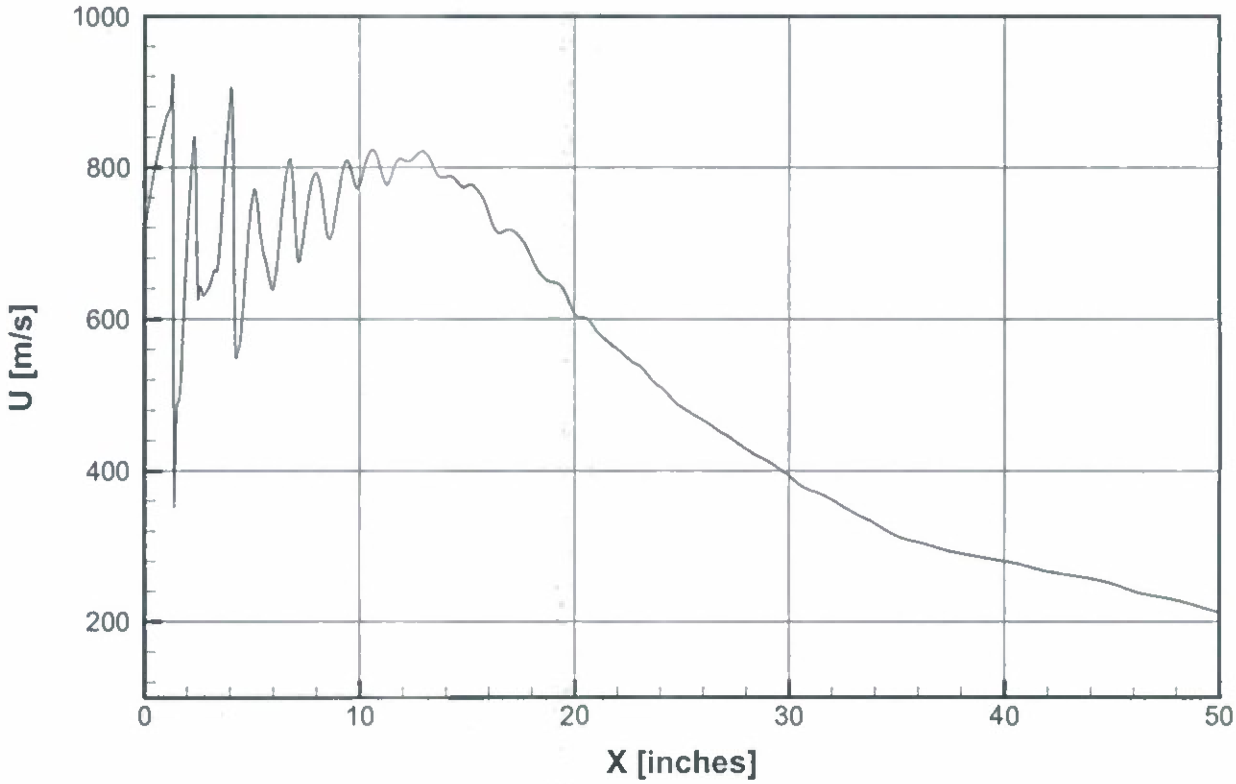

Figure 15. Decay of the streamwise velocity along the nozzle axis for the conic nozzle configuration with the centerbody operating at correctly expanded conditions.

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3 Technical/Cost Status & Problem Areas

3.1 Technical Status

Technically the program is on schedule. The week of April 23-27 was targeted early on as the goal for performing the collaborative experiment, and with the contributions of all the team members, we successfully met that goal. Now, we are all working diligently on analyzing the data gather from the February and April experiments.

The April experiments opened a window to another potential method of flow measurement with the PBL system. As with any experimental program, the continual development of the diagnostic tools leads to new ideas. These ideas will be integrated into plans for further testing as we complete Year 1 and move into Year 2.

3.2 Cost Status

NCPA recently received the remainder of Year 1 funding and completed subcontract modifications for the other team members.

Due to the run times required to collect a statistically relevant data set with the MHz PIV system (as it is currently operated), the cost for facility operation has been significantly higher than anticipated. To date, these cost over-runs are primarily in expendable supplies (i.e. propane fuel) which have been covered by NCPA overhead funds.

3.3 Problem Areas

The two technical problem areas are in the jet seeding system and the operation of the Cordin camera. Plans to resolve these issues are in place:

- NCPA will move to build and install a pH-Stabilized seeding system for future testing.
- With a knowledge of experiment operation and a clearer definition of the requirements, Auburn U. will work with Cordin to implement software improvements to allow the camera to operation to be enhanced.

4 Publications, Meetings, and/or Travel

- An invitation was received from the organizing chair of the ASME/NCAD INTER-NOISE 2012 conference (P. Morris) to present current results from this program at the August meeting.

5 Planned Activities for Next Reporting Period

Plans for the coming reporting period include:

- Analysis of February and April data.
- Experiments for comparison to CFD phased-array methods.
- Near-field noise directivity measurements.

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- Submission of a manuscript for the ASME/NCAD INTERNOISE 2012 conference.
- Attendance at the year end review meeting (scheduled for 17 July 2012).

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