



Fundamental Aeronautics Program

Supersonics Project

Channeled Center-body Inlet Experiment Overview

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Channeled Center-body Inlet Experiment: Outline

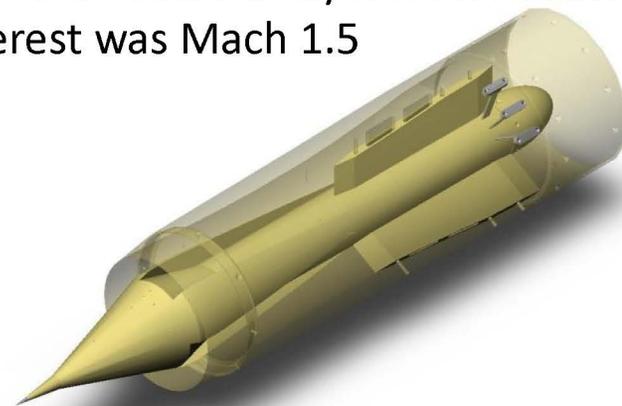
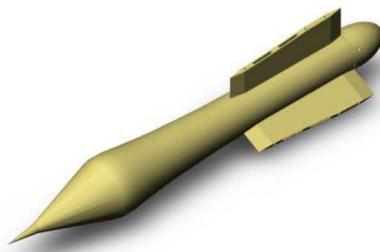
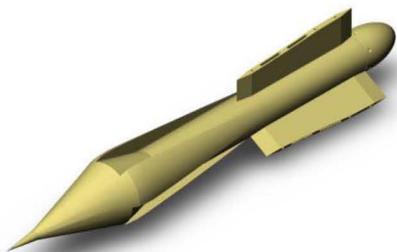


- Experiment Description
 - Overview
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 - Flight Test Objectives
 - Test Points
 - Instrumentation
- Precursor Testing
- Flights
- Preliminary Data
- Future Work

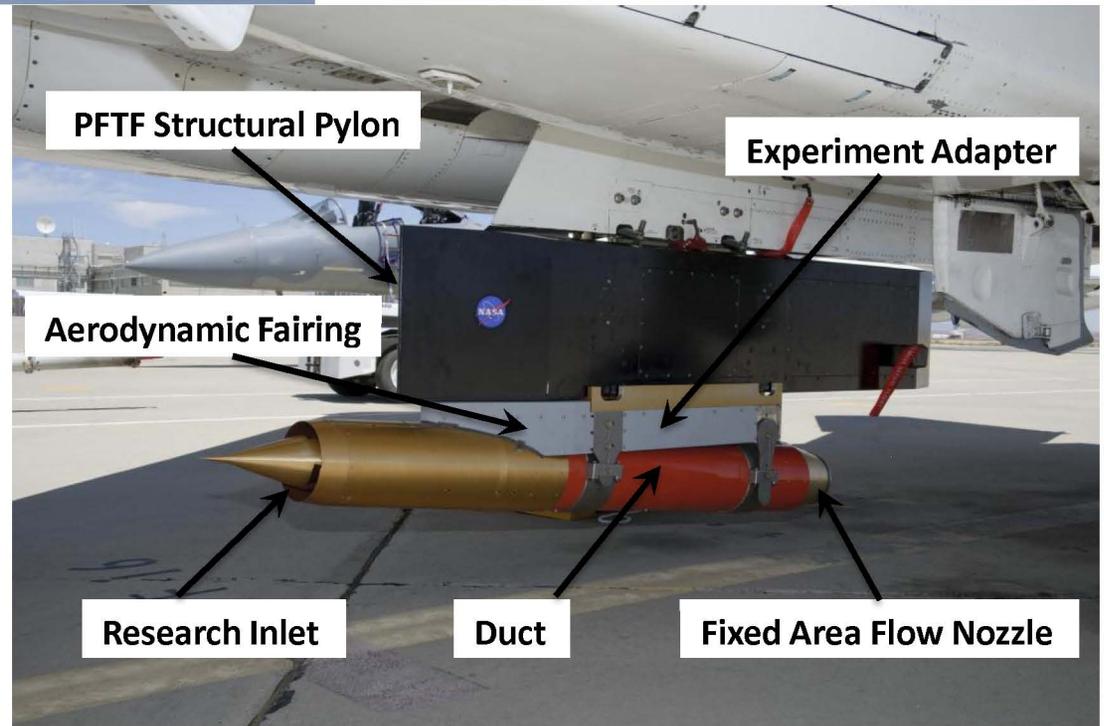
Channeled Center-body Inlet Experiment: Experiment Description - Overview



- Proof of concept experiment flown on NASA's F15B T/N 836
 - Tested biconic supersonic inlet concept developed by Techland Research Inc. via a NASA SBIR contract
 - Inlet design features a unique method of off-design flow matching via movable channels rather than translating center-body
 - Pressure data was collected over a series of off design Mach numbers and mass flow conditions for two fixed geometry inlet configurations to determine differences between the two (with emphasis placed on distortion) as well as for comparison to CFD
 - Channeled Center-body
 - Equivalent Area Smooth Center-body
 - The design Mach number for the channeled center-body inlet is Mach 2.5, and the off-design condition of primary interest was Mach 1.5



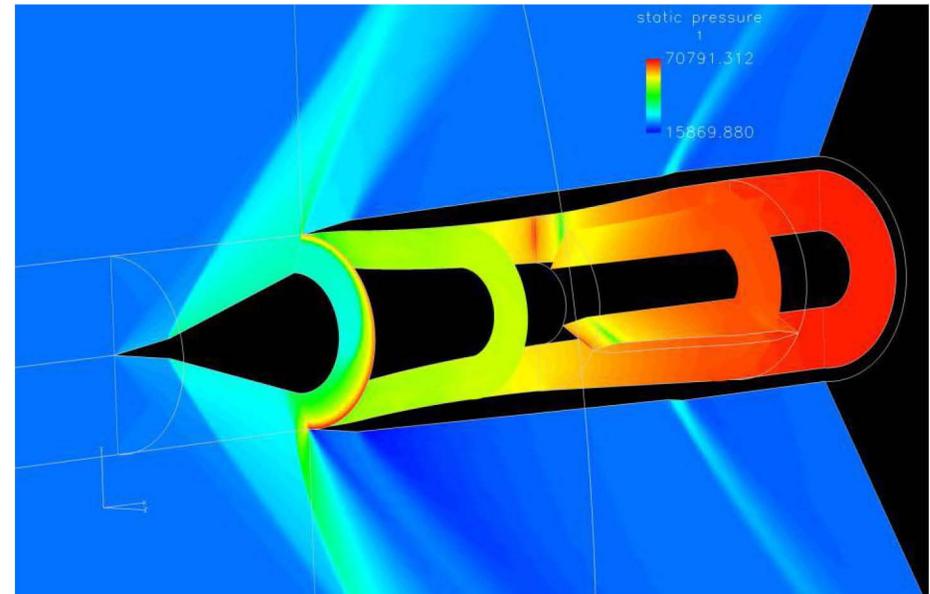
Channeled Center-body Inlet Experiment: Experiment Description - Configuration



Channeled Center-body Inlet Experiment: Experiment Description – Flight Test Objectives



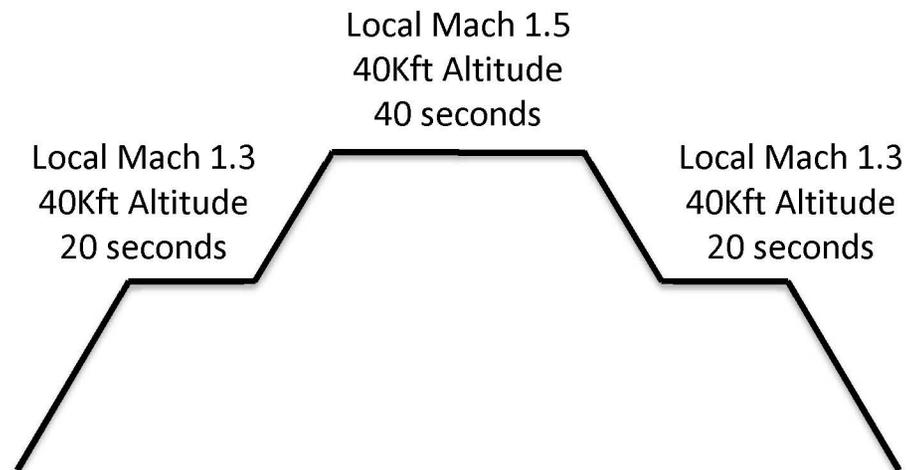
- The primary research objective was to define the channeled center-body inlet flow as well as the equivalent area smooth center-body flow, and compare the two at off-design conditions. ***Evaluate the concept against the current norm for axisymmetric.***
- The secondary research objective is to compare these flight results with current CFD predictions. ***Evaluate CFD predictive / design capabilities.***



Channeled Center-body Inlet Experiment: Experiment Description – Test Points (planned)



- Six configurations were planned for flight
 - Two center-body configurations
 - Three fixed geometry nozzles to set mass flow
- Two steady state test points planned per flight (Local Mach 1.3 and 1.5 at Aircraft Altitude of 40,000 ft)



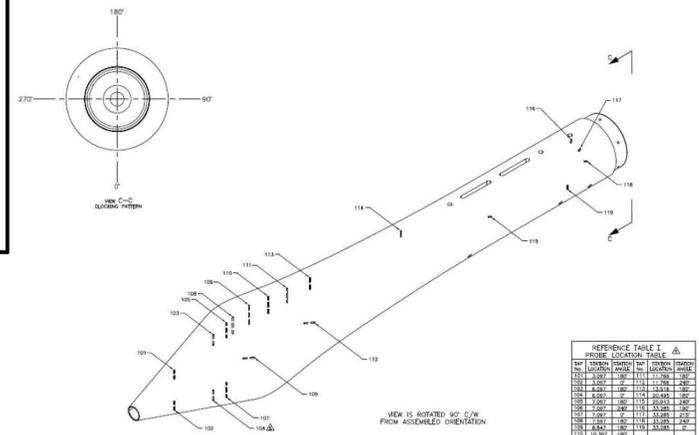
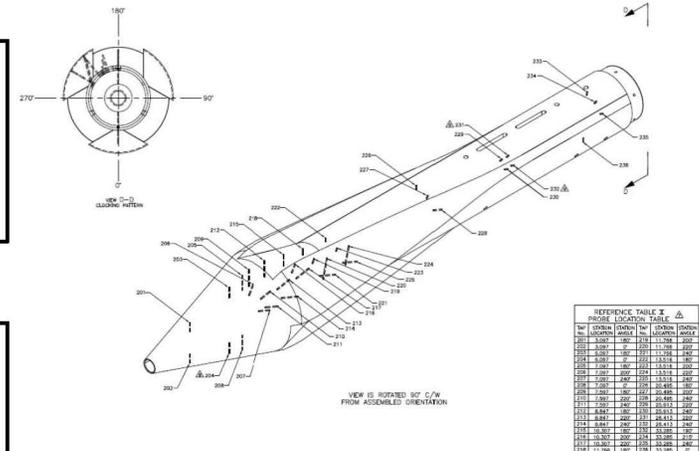
Channeled Center-body Inlet Experiment: Experiment Description – Instrumentation



F-15B Parameters	Qty	Range		Eng. Units	SPS
		Min	Max		
Noseboom static pressure		0	19	psi	100
Noseboom total pressure		0	38	psi	100
Aircraft total temperature		-134	247	degF	20
Noseboom angle of attack, deg		-16	46	deg	50
Noseboom angle of sideslip, deg		-30	30	deg	50

Primary Experiment

Experiment Total pressure, cone-probe	1	0	20	psia	100
Experiment Static pressure, cone-probe	4	0	7	psia	100
Cowl Static pressure	4	-10	10	psid	50
Cowl Kulite	1	0	15	psia	800
Smooth Centerbody Static pressure	18	-10	10	psid	50
Channeled Centerbody Total pressure	2	-30	30	psid	50
Channeled Centerbody Static pressure	33	-10	10	psid	50
Rake Total pressure	15	-30	30	psid	50
Rake Static pressure	3	-10	10	psid	50
Nozzle Static pressure	4	-10	10	psid	50
Reference tank pressure	1	0	15	psia	50



Channeled Center-body Inlet Experiment: Precursor Testing



- PFTF Envelope Expansion / Cone Drag Experiment (CDE) 2001/2002
 - Performance -- defined max Mach test capability
 - Propulsion -- assessed force balance function, accuracy, and repeatability
 - Aerodynamics/propulsion -- assessed local flow quality
 - Verified acceptable handling quality characteristics
 - Instrumentation -- verified system function
 - Structural dynamics -- flutter clearance
- Local Mach Investigation (LMI) 2004
 - Provided local flow data for future propulsion flight experiments.

Channeled Center-body Inlet Experiment: Precursor Testing



Rake Airflow Gage Experiment (RAGE) 2008/2009

- Characterized flowfield at multiple locations on the inlet aerodynamic interface plane at the centerbody tip before flight test of the Channeled Centerbody Inlet Experiment
- Better enabled CFD comparisons by examining flow uniformity for more of the stream tube to be ingested

Channeled Center-body Inlet Experiment: Flights – Test Points (flown)



Date	CCIE Flight	Centerbody	Ath/Ain	836 Flight	Result
8/17/2011	1	Channeled	0.529	416	Steady state data collected at local Mach 1.3 and 1.5
8/22/2011	2	Channeled	0.532	417	Flight aborted, no data collected due to aircraft left engine compressor stall
8/26/2011	3	Channeled	0.532	418	Flight aborted, no data collected due to aircraft left engine compressor stall
10/18/2011	4	Channeled	0.532	419	Steady state data collected at local Mach 1.3, ~1.46 (axial), & 1.5
10/20/2011	5	Channeled	0.548	420	Steady state data collected at local Mach 1.3, ~1.46 (axial), & 1.5
11/8/2011	6	Smooth	0.529	421	Steady state data collected at local Mach 1.3, ~1.46 (axial), & 1.5
11/14/2011	7	Smooth	0.532	422	Steady state data collected at local Mach 1.3, ~1.46 (axial), & 1.5
11/16/2011	8	Smooth	0.548	423	Steady state data collected at local Mach 1.3, ~1.46 (axial), & 1.5
12/14/2011	9	Smooth	0.532	424	<i>Additional test points for local flow investigation flown. Data collected in level accel from local Mach 1-1.65</i>
1/5/2012	10	Smooth	0.532	426	<i>Repeat of Flight 422 local Mach 1.5 test point, and additional test points for test method evaluation: 0.5-2.0 G POPU performed to examine transients and a series of points varying angle of attack by varying local Mach and holding mass flow constant by varying altitude were performed.</i>

Channeled Center-body Inlet Experiment: Flights – Additional Test Points



- The CCIE on 836 offered an opportunity to obtain additional local flow and inlet performance data that would directly benefit CCIE and future experiments using the PFTF
 - Further quantified the local flow underneath the airplane
 - Gathered additional inlet performance data to provide additional flight data to benchmark computational models and aid in the design of future PFTF experiments
 - Evaluate test techniques and transient angle of attack capability
- The objectives of the additional flight were as follows:
 - 1) Characterize the local flow field out to a higher local Mach number (nominally 1.65 local Mach)
 - 2) Obtain steady state ECB data at 1.49 local Mach (repeated test point)
 - 3) Determine how changes in aircraft angle of attack affect the local flow properties and the inlet performance (POPU)
 - 4) Characterize inlet performance with respect to local flow angle, controlling for a constant mass flow rate

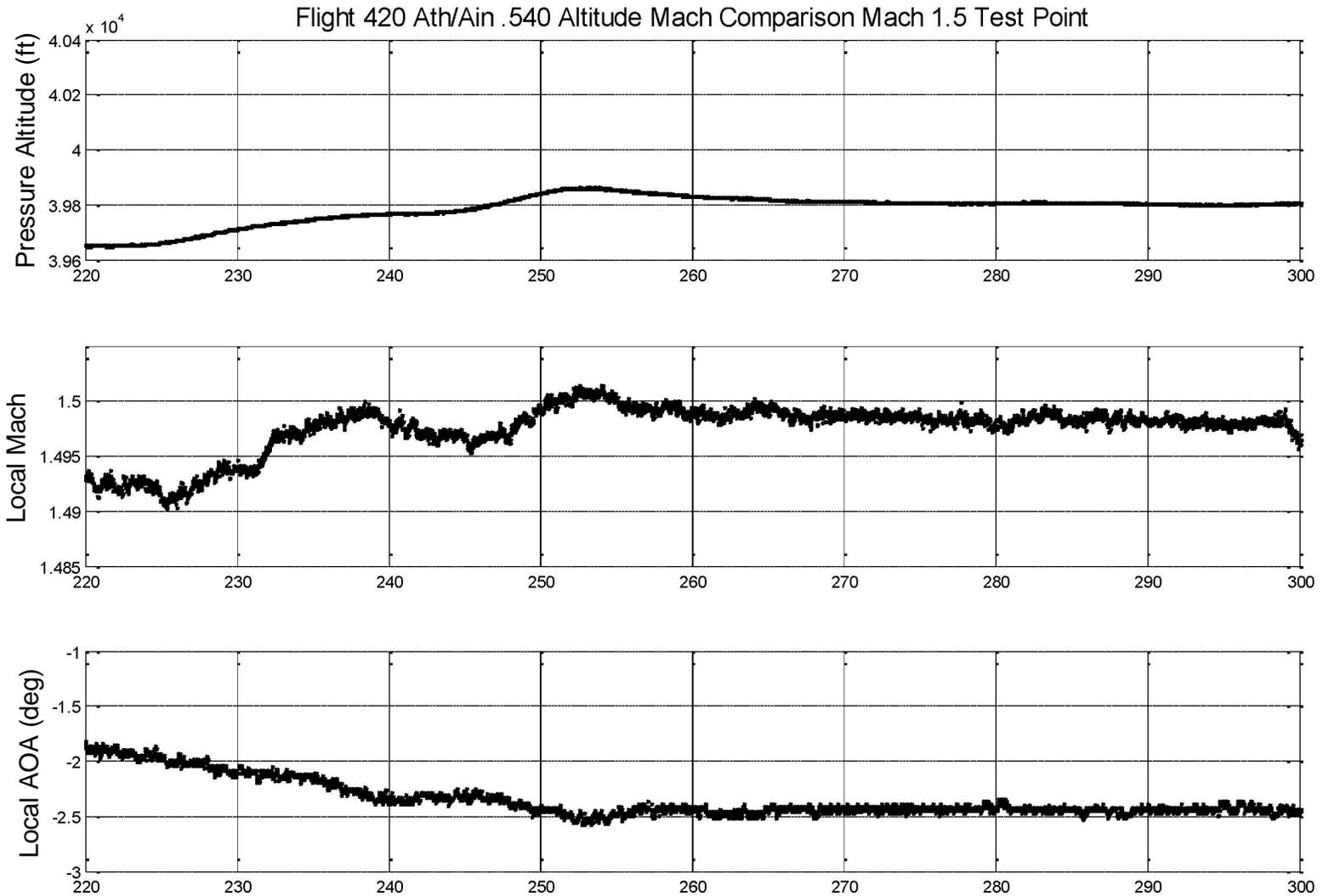
Channeled Center-body Inlet Experiment: Flights – Additional Test Points



Objective	CB	$\frac{A_{th}}{A_{in}}$	Local Mach Number	Aircraft Mach Number	Aircraft Altitude [Kft]	Local Qbar (psf)	Aircraft Qbar (psf)	Maneuver
Local Flow/Inlet Performance	Smooth	0.532	1.0-1.65	1.0-1.9	40	300-1000	300-989	Accel
Local Flow/Inlet Performance	Smooth	0.532	1.65	1.9	40	1000	989	Steady
Inlet Performance	Smooth	0.532	1.49	1.65	40	746	746	Steady
Local Flow/Inlet Performance	Smooth	0.532	1.49	1.65	40	746	746	0.5-2g POPU
Flow Angle - 2.0°	Smooth	0.532	1.47	1.60	39.1	731	734	Steady
Flow Angle - 1.0°	Smooth	0.532	1.43	1.50	36.1	735	737	Steady
Flow Angle 0.0°	Smooth	0.532	1.39	1.41	33.4	742	743	Steady
Flow Angle + 1.0°	Smooth	0.532	1.36	1.33	30.1	752	753	Steady
*Flow Angle + 2.0°	Smooth	0.532	1.32	1.28	28.6	766	766	Steady

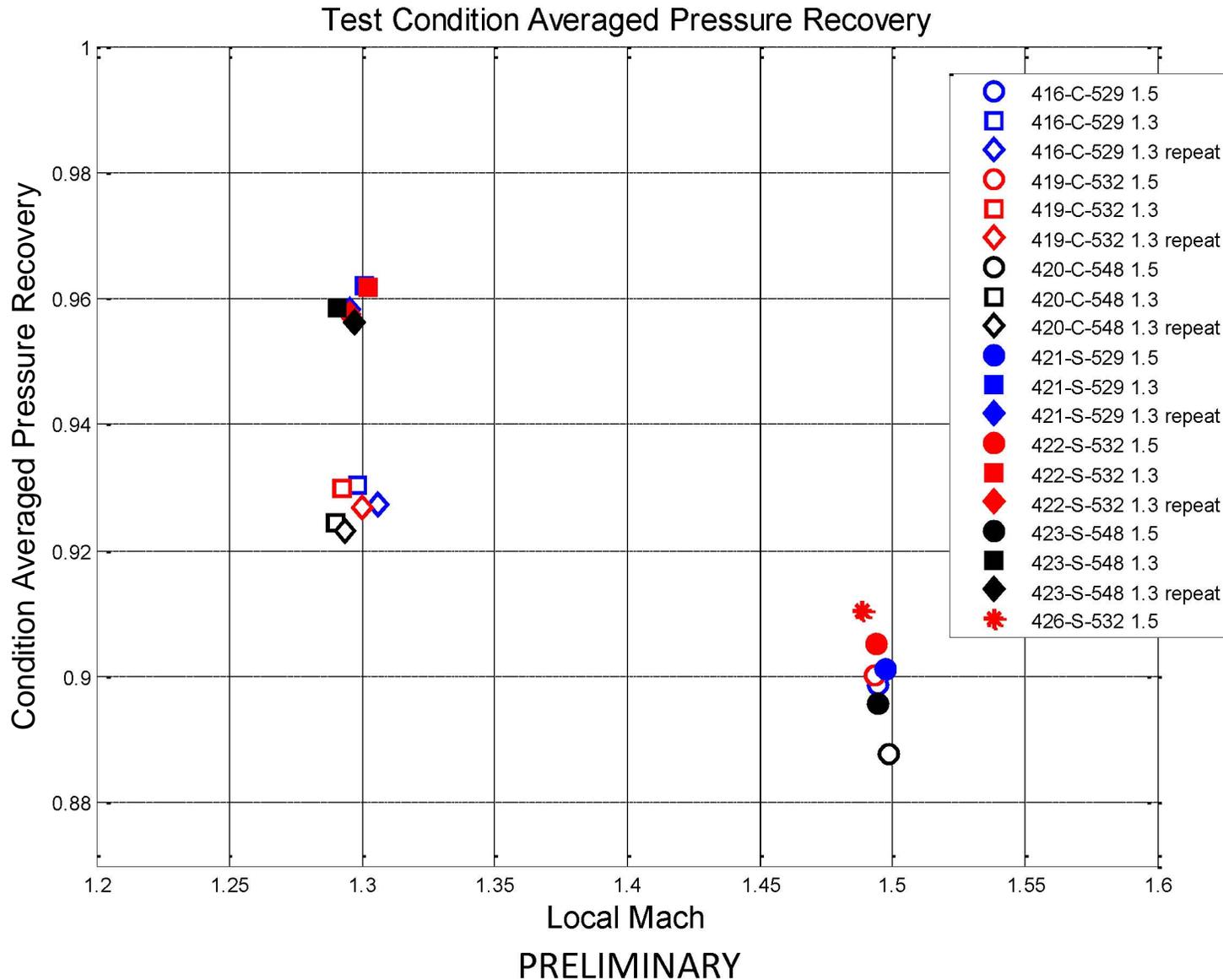
* Not Flown

Channeled Center-body Inlet Experiment: Preliminary Data – Test Conditions (representative)

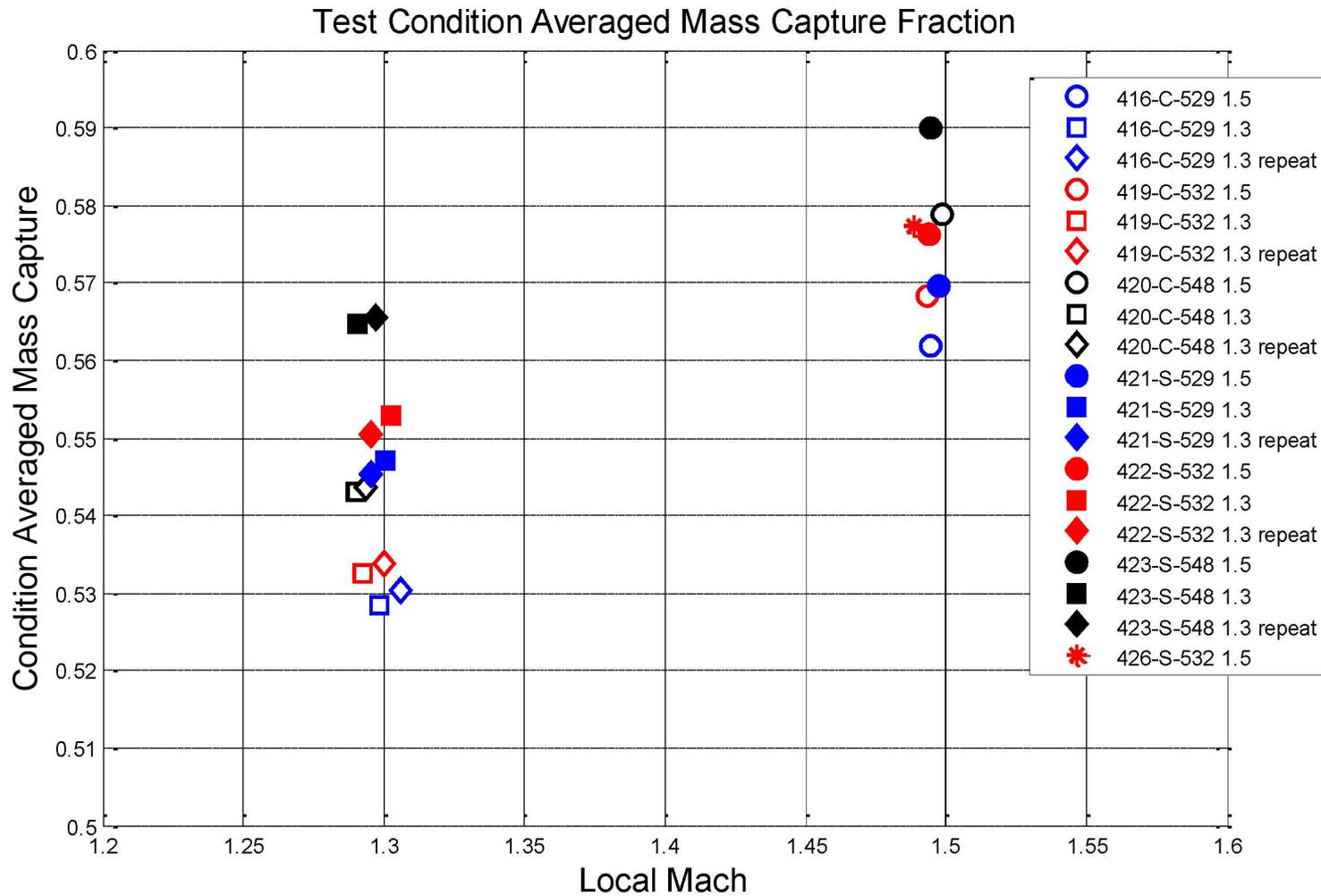


PRELIMINARY

Channeled Center-body Inlet Experiment: Preliminary Data – Pressure Recovery

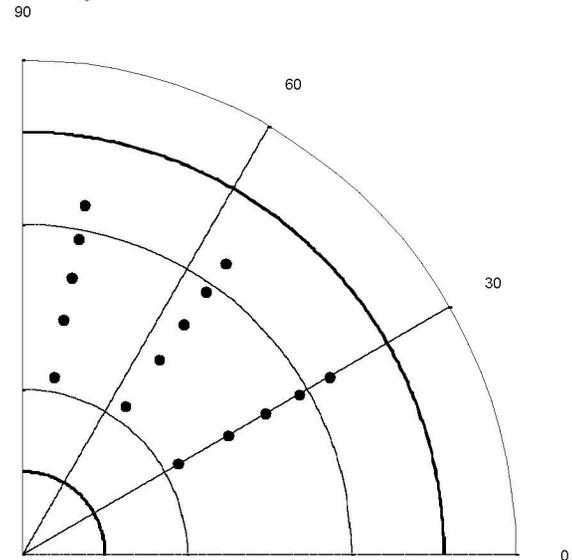
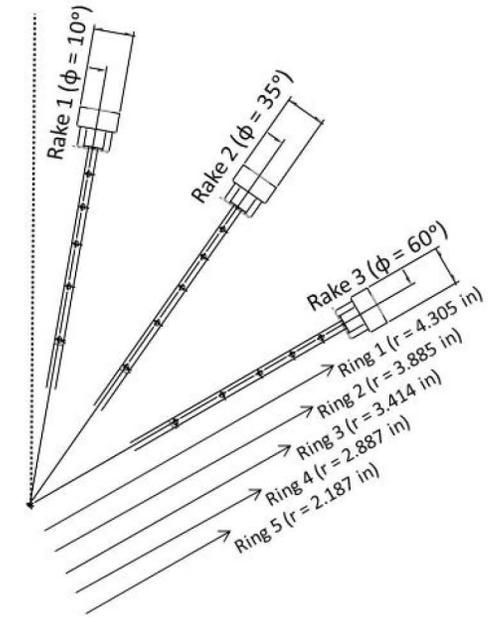
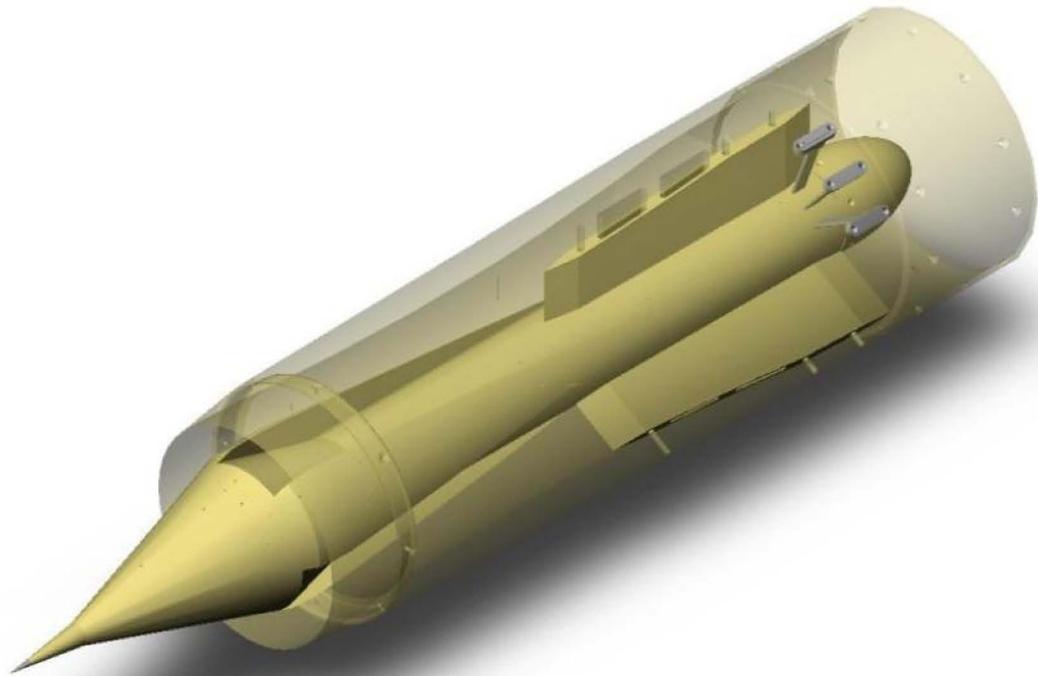


Channeled Center-body Inlet Experiment: Preliminary Data – Mass Capture Fraction

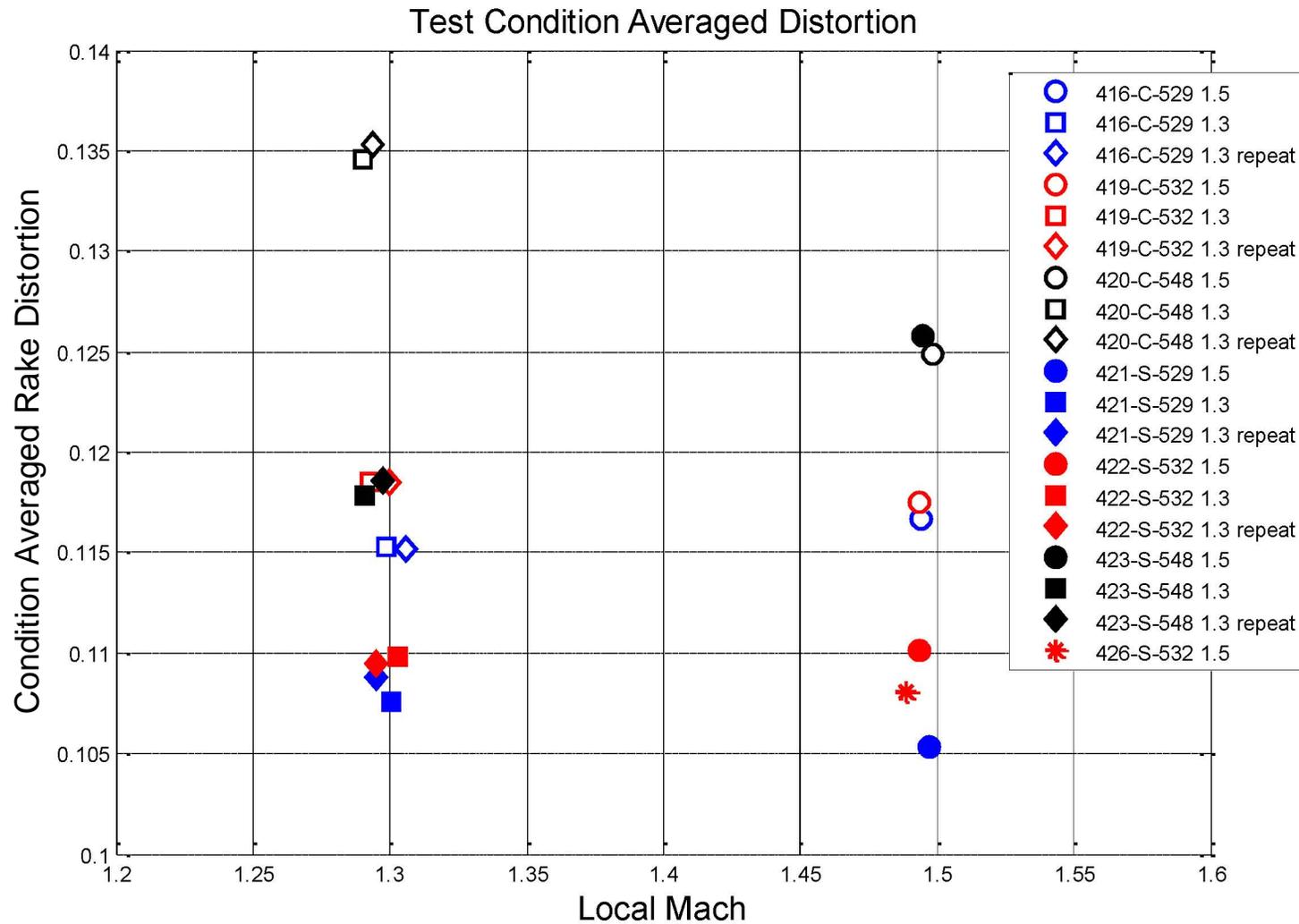


PRELIMINARY

Channeled Center-body Inlet Experiment: Preliminary Data – Distortion Rake Port Locations

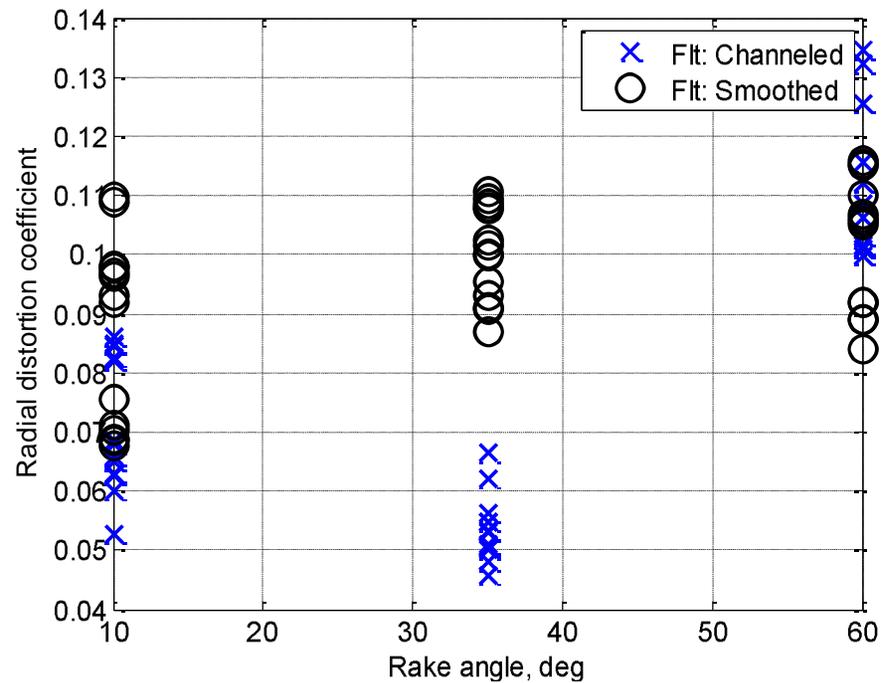
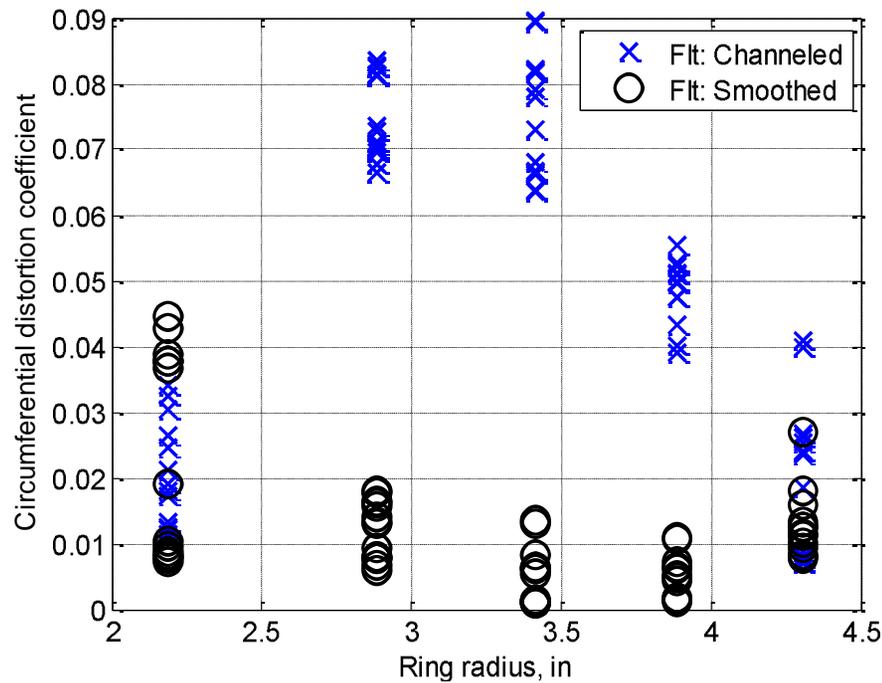
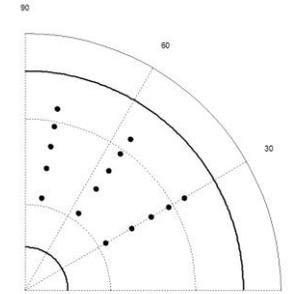


Channeled Center-body Inlet Experiment: Preliminary Data – Distortion (basic)



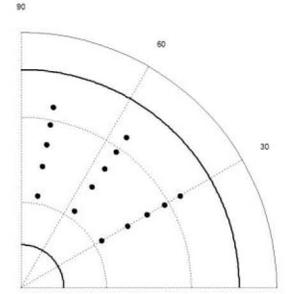
PRELIMINARY

Channeled Center-body Inlet Experiment: Preliminary Data – Distortion (basic) separated by component

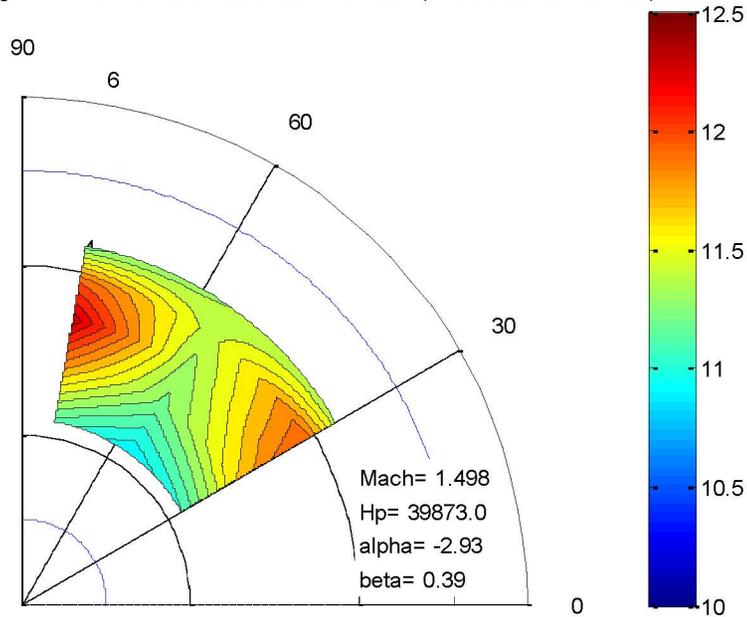


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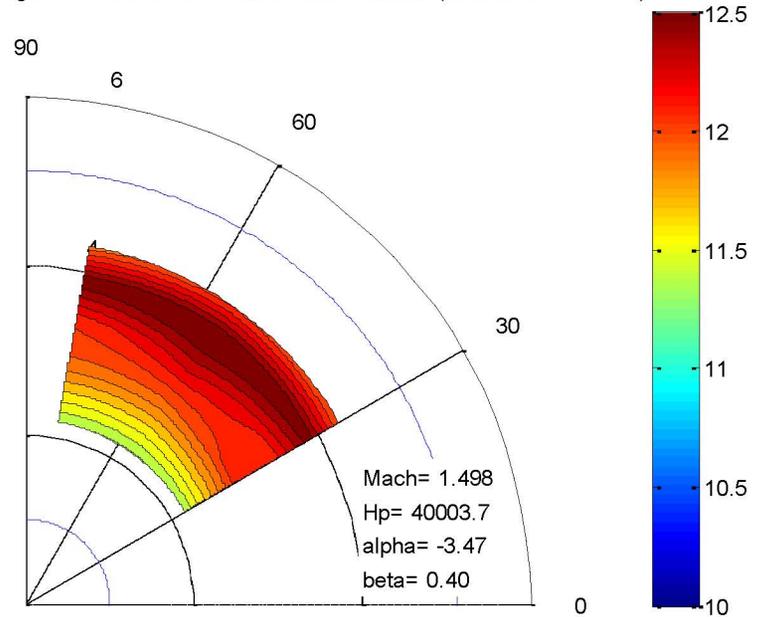
Channeled Center-body Inlet Experiment: Preliminary Data – Total Pressure Contours



Flight 416 Ath/Ain .529 Rake Total Pressure (Channeled M=1.5 Run)



Flight 421 Ath/Ain .529 Rake Total Pressure (Smooth M=1.5 Run)

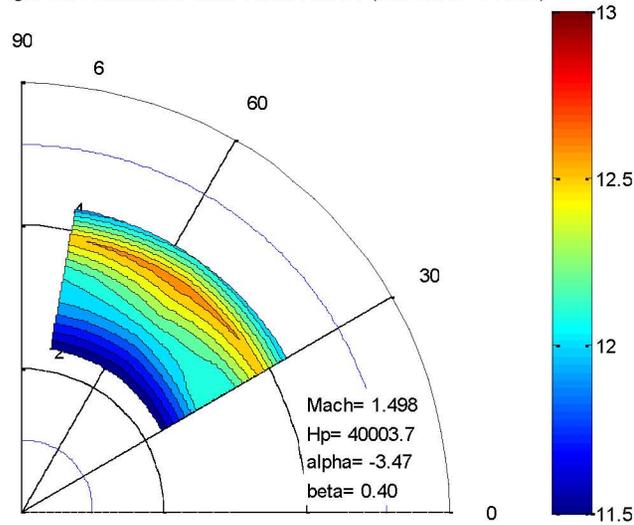


PRELIMINARY

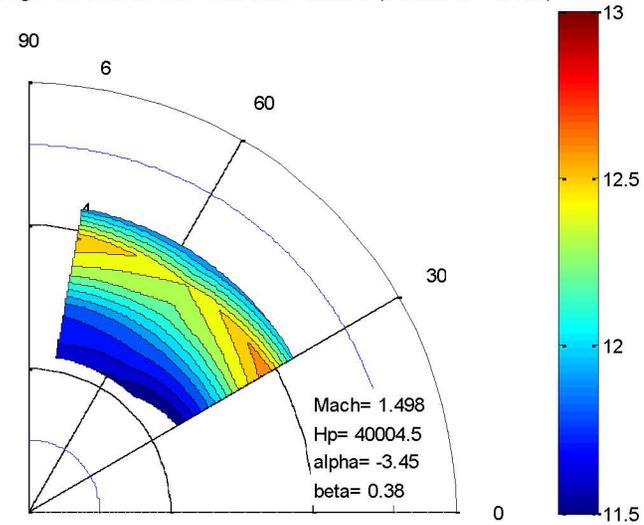
Channeled Center-body Inlet Experiment: Preliminary Data – Total Pressure Contours (Smooth variation)



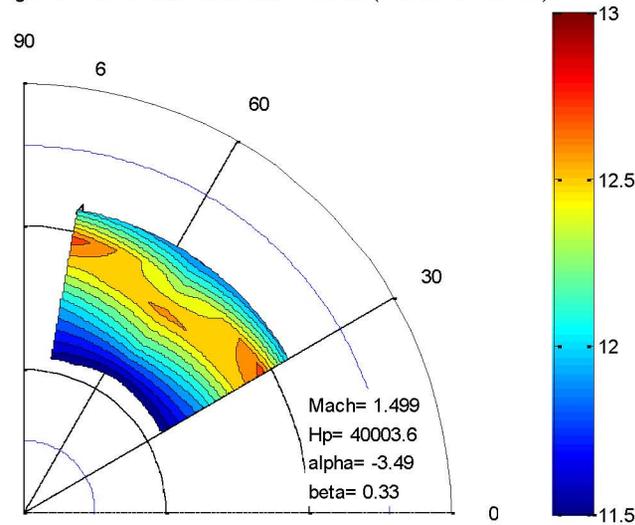
Flight 421 Ath/Ain .529 Rake Total Pressure (Smooth M=1.5 Run)



Flight 421 Ath/Ain .529 Rake Total Pressure (Smooth M=1.5 Run)

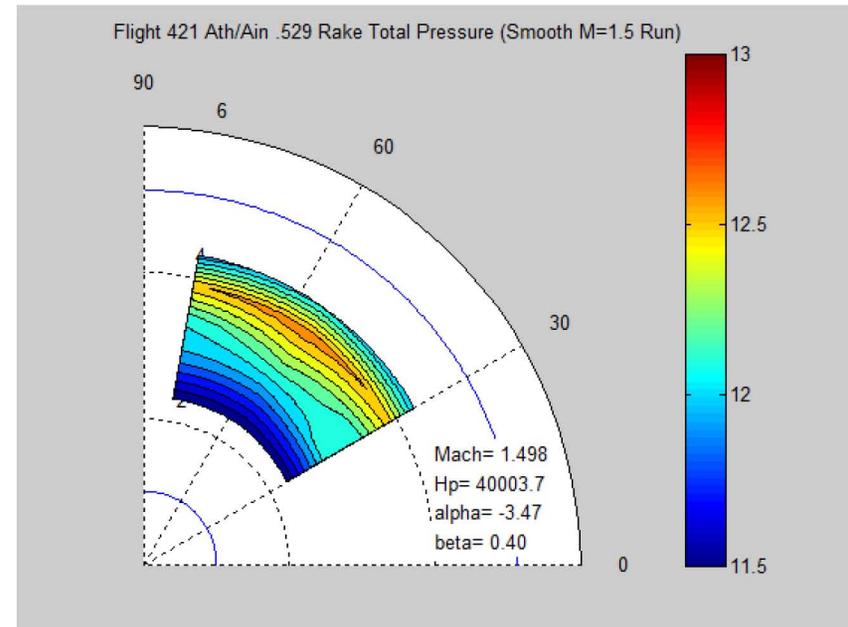
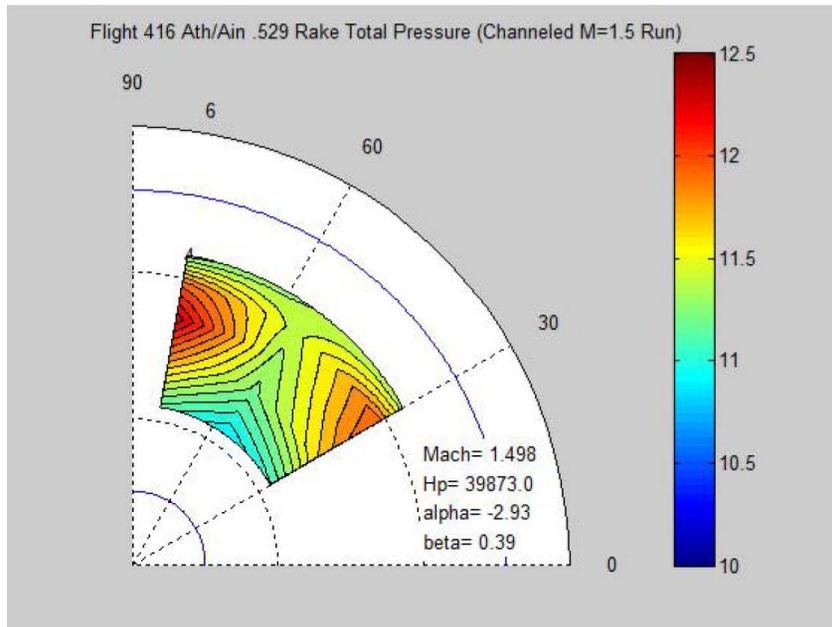


Flight 421 Ath/Ain .529 Rake Total Pressure (Smooth M=1.5 Run)



PRELIMINARY

Channeled Center-body Inlet Experiment: Preliminary Data – Total Pressure Contours (movies)



PRELIMINARY

Channeled Center-body Inlet Experiment: Future Work



- Data analysis and comparisons
 - Flight to Flight
 - Flight to CFD
- Data sharing
 - Data to GRC and Techland Research Inc
 - Data to Naval Air Warfare Center, Weapons Division at China Lake
- Reporting
- Extended capabilities studies
 - Variable geometry nozzle (turn 6 flights into 2-4 flights)
 - Force balance updates / calibration
 - Splitter plate to clean up local flow
- Examine follow on testing possibilities
 - Buzz studies in flight
 - If warranted further examination of channeled center-body configuration
 - Full-face distortion measurements
 - Distortion correction (flow fences etc)

