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On-Line Distortion Analysis System for Inlet-Engine Testing*

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NOMENCLATURE

AEDC	Arnold Engineering Development Center
AIP	Aerodynamic Interface Plane
ASTF	AEDC Aeropropulsion Systems Test Facility
DDA	Digital Distortion Analyzer
C-1	ASTF Test Cell C-1
C-2	ASTF Test Cell C-2
FM-MPX	Frequency Modulated Multiplexed
Gbytes	One billion bytes (8 bits) of digital information
IDC	Index of circumferential distortion
IDR	Index of radial distortion
I/O	Input/Output
K	One thousand
KA2	Pratt and Whitney engine-face distortion index
kbytes	One thousand bytes (8 bits) of digital information
M	One million
Mbytes	One million bytes (8 bits) of digital information
MHz	One million Hertz (cycles per second)
PWT	AEDC Propulsion Wind Tunnel
THEXT	Continuous circumferential extent, in degrees, over which the pressure is less than the average pressure
16S	PWT 16-ft Supersonic Wind Tunnel
16T	PWT 16-ft Transonic Wind Tunnel

INTRODUCTION

Pressure and temperature distortion play an important role in aircraft/engine compatibility evaluations and testing for all turbine-engine/aircraft installations and particularly the multirole advanced tactical fighters currently being developed by the U.S. Air Force (Amundson and Holm, 1989). Several methodologies for analyzing the time-dependent, spatial, engine-face total pressure distortion have been developed over the past 25 years. The following is indicative of the various approaches but is by no means a complete list.

Statistical techniques have been applied to the time-dependent signals obtained from inlet-engine instrumentation to predict the "worst-case instantaneous" distortion (Borg, 1981; Costakis, 1974; Melick et al., 1976; Motycka, 1976; Sedlock, 1984). In general, these techniques have had some success but require extensive empirical databases. Analog computers have been used to compute real-time approximations of complex inlet distortion parameters for large amounts of data to locate "worst-case" conditions (Perrier et al., 1981). Alternatively, analog computers have been used to screen data for later digital processing at selected times.

This approach (analog computer screening followed by selected digital processing) has been used for the past several years to analyze inlet-engine distortion

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data acquired at the Arnold Engineering Development Center (AEDC). Application of this approach required that the distortion data magnetic tapes be duplicated and sent to the Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio for processing on the Dynamic Data Editing and Computing System (DYNADEC). DYNADEC uses a hybrid analog-digital computer to determine the maximum instantaneous distortion (Marous and Sedlock, 1980). The analog computer provides continuous calculation of distortion parameters including KA2. To determine the maximum distortion for a given data point, KA2 is continuously screened as data are reproduced from magnetic tape. A peak detector locates the maximum value of KA2. The instantaneous pressure measurements associated with the maximum value of KA2 are recorded and output as engine-face contour maps along with digitally computed values for KA2 and other distortion parameters. These results were then returned to AEDC for analysis. If significant distortion activity was indicated, portions of the data near the indicated peaks were reproduced from the original magnetic tape and digitized for additional analysis on a general purpose digital computer.

In addition to a long data turnaround time of typically four weeks, this process only provided detailed digital analysis of a limited portion of the data (near the peak values). It was also limited in flexibility to compute different or modified distortion indices, and had no capability for AEDC analysis engineers to interact with the screening process and compute distortion parameters at other points of interest. As a result, increased test time was used to acquire backup data points at conditions that spanned anticipated points of interest since the lack of analysis results during testing made it impossible to "tune-in" on-line. Further, the analog computer typically only approximated the distortion index, thus introducing potential errors in defining "worst-case" for correlation to other observed events such as engine surges.

Direct digital calculation of distortion indices in near-real-time has been accomplished (Boccadoro et al., 1985; Eyraud et al., 1986) and represents the best technical approach to the problem. However, the processing speeds needed for practical on-line use during testing required low-level programming of the index calculation algorithms in machine or assembly language. While providing for efficient execution of the computational algorithms, this method requires large amounts of programming time and even minor changes in methodology are not easily incorporated in the computations. For example, Eyraud et al. (1986) indicates that 4,000 lines of assembly level coding is required to meet the processing requirements.

Although a basic inlet distortion analysis methodology has been established (SAE ARP-1420, 1977), applications of that methodology to specific engine development programs have resulted in many variations in the actual computational algorithms. Testing at the AEDC is conducted for a wide range of manufacturers who have unique algorithm requirements. Therefore, an approach permitting high-level (e.g., FORTRAN) language coding is required to minimize implementation times for unique algorithms. The system now in use at AEDC meets these requirements. The objective of this paper is to describe this system and its capabilities and initial applications.

SYSTEM/TEST FACILITY OVERVIEW

The AEDC distortion analysis system, Fig. 1, is comprised of a central digital distortion analyzer (DDA) with interfaces for input of data from inlet-engine tests in the 16T and 16S wind tunnels in the Propulsion Wind Tunnel (PWT) and altitude test cells C-1 and C-2 in the Aeropropulsion Systems Test Facility (ASTF). The PWT 16T and 16S wind tunnels have 16- × 16- × 40-ft test sections and are used for aerodynamic and propulsion testing of full-scale inlets, engines, and inlet-

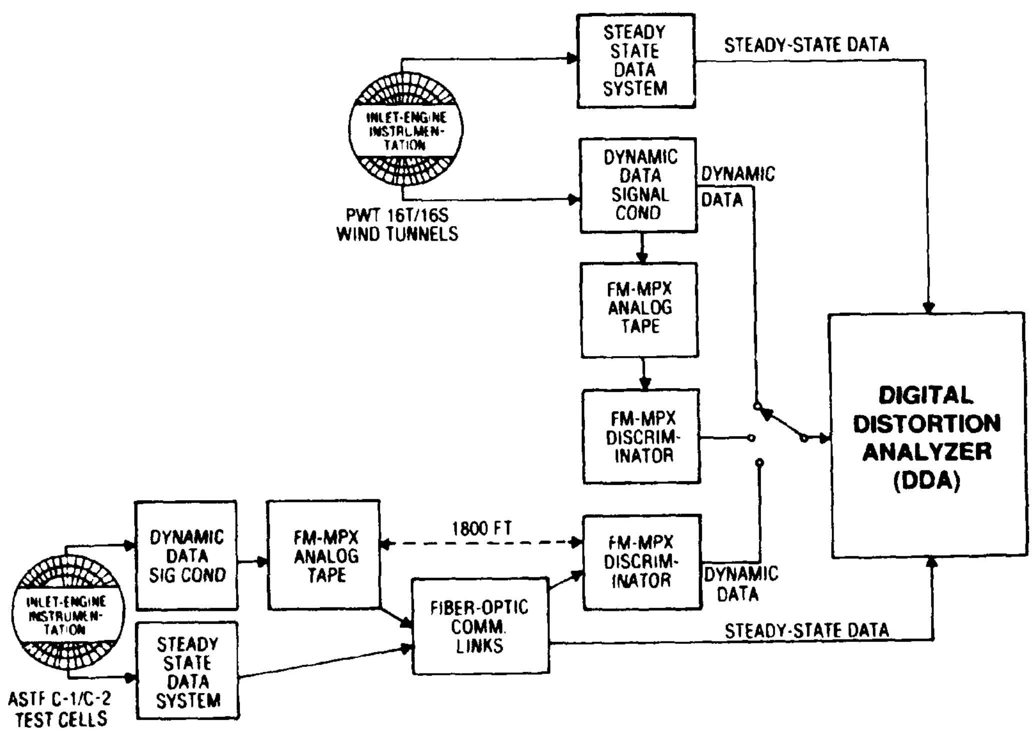


Fig. 1. AEDC distortion analysis system.

engine installations as well as large-scale aircraft models. The 16T and 16S tunnels have Mach number ranges of 0.06 to 1.60 and 1.50 to 4.75, respectively. ASTF test cells C-1 and C-2 have test sections that are 28 ft in diameter and 85 ft long. These test cells are used in direct-connect and free-jet configurations for propulsion testing of engines and engine-inlet installations at simulated flight conditions up to 100,000 ft in altitude and Mach 3.8 with airflow rates up to 1,450 lbm/sec.

SYSTEM DESCRIPTION

As shown in Fig. 1, inlet-engine data are input to the digital distortion analyzer (DDA) from the steady-state and dynamic data acquisition and processing systems in PWT and ASTF. Although the DDA supports testing in both PWT and ASTF, it is operated in a dedicated mode and only supports one test program at a time.

Steady-state data are input in digital engineering unit format over an Ethernet communication link for both PWT and ASTF. For PWT, high-response data are input to the DDA in analog format directly from the dynamic data signal conditioning. For ASTF, however, because of its remote location with respect to the DDA, dynamic data is transmitted via fiber optics in frequency modulated multiplex (FM-MPX) format and converted back to analog for input. In both PWT and ASTF, dynamic data are recorded on magnetic tape in FM-MPX format for permanent archival and off-line processing.

Hardware Configuration

The DDA consists of a host computer system, an analog-to-digital conversion system, a high-speed input/output (I/O) computer system, and three array processors as shown in Fig. 2.

The DDA host computer is a Digital Equipment Corporation (DEC) MicroVax III with 16 Mbytes of main memory. The host computer system includes a DEC TK50, 95-Mbyte cartridge tape; two Fujitsu Model 2351, 474-Mbyte SMD (storage module drive) disks; a DEC LN03 laser printer; two Tektronix 4224 color graphics terminals; an Ethernet interface; operator terminals; and interfaces to the analog-to-digital converter, high-speed I/O computer, and array processor systems.

The DDA analog-to-digital conversion system provides time-correlated digitization of up to 64 analog input channels. A 64-channel, 6-pole/6-zero, linear phase, constant time-delay filter system (Precision Filters Model 6604-A-TD1-CDM) is used to prevent aliasing of digitized data. Each filter has a differential input and programmable cutoff frequencies of 1 to 1,023 Hz (in 1 Hz steps) and 1,025 to 25,575 Hz (in 25-Hz steps). Analog-to-digital conversion (ADC) is provided by a Tustin Model 2315-126DS-120 ADC system. This system has a resolution of 15 bits with an accuracy of ±0.03 percent of full scale and includes a differential sample-and-hold amplifier per channel for time-correlation. Although the ADC is capable of digitizing at a 1-MHz rate, the rate at which data can be transferred to disk storage limits the useable throughput to 640 kHz and results in a maximum rate of 10,000 samples/channel/sec for 64 channels.

An APTEC Model 2400 Input/Output (I/O) computer is interfaced to the host computer to provide the rapid transfer rates required during acquisition and processing of time-dependent distortion data. The APTEC I/O computer system has 4 Mbytes of memory and also includes four Fujitsu Model 2351, 474-Mbyte SMD disk drives; a 9-track, 1600/6250-bpi digital magnetic tape; a Honeywell VLDS (very large data store) VHS digital cassette tape recorder; and interfaces to the analog-to-digital conversion system and three array processors. The I/O computer provides a 32-bit bus capable of transferring data at a 24-Mbyte/sec rate. Data may be transferred between the I/O computer memory and any device on the I/O computer bus without incurring any host computer overhead or loading. Any device on the I/O computer bus may also be accessed by the host computer. However, when

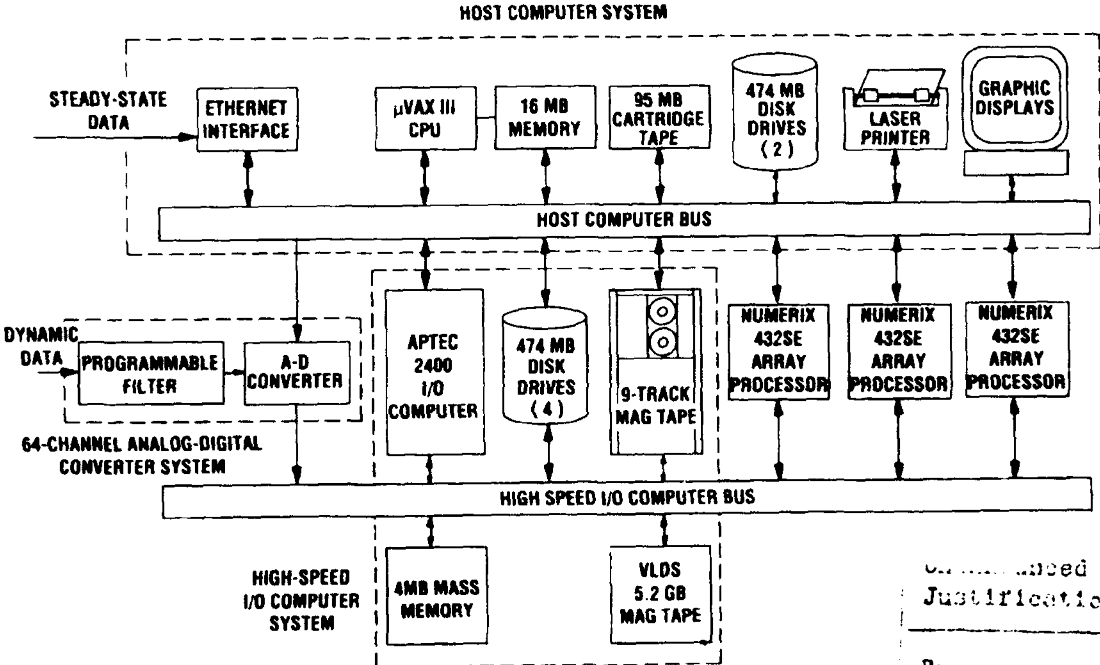


Fig. 2. Digital distortion analyzer block diagram.

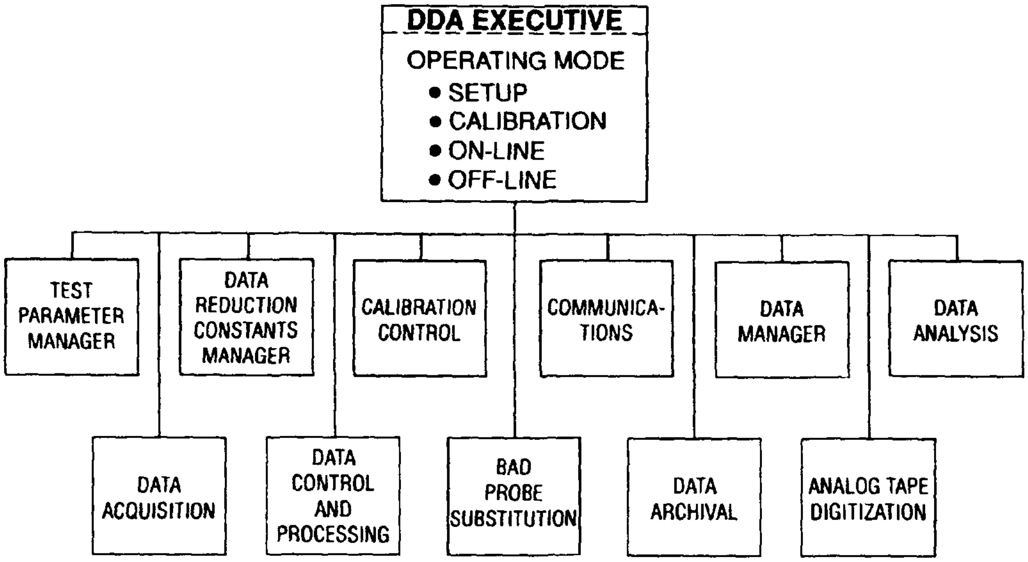


Fig. 3. DDA operating software configuration.

accessing devices in this mode the transfer rate is reduced because of the host computer's slower bus rate and operating system overhead.

During data acquisition, the disk drives temporarily store digitized data for quick access during data processing. Each disk drive can store 181 million data samples at a maximum transfer rate of 640,000 samples/sec. For permanent storage, data is transferred from disk to 9-track or VLDS cassette tapes. The 9-track tape stores approximately 70 million data samples (140 Mbytes) on a single reel of tape with a transfer rate of 250 kbytes/sec. The VLDS cassette tape stores 2.6 billion data samples (5.2 Gbytes) on a single VHS tape cartridge with a maximum instantaneous transfer rate of 2 Mbytes/sec.

Three Numerix 432SE array processors are interfaced to the I/O computer for high-speed execution of distortion analysis algorithms. Each array processor has 16K words of program storage memory, 64K words of static data memory, and 2M words of dynamic data memory. Data may be transferred between the I/O computer and the array processors at more than 2 Mbytes/sec. Programs for the array processors are developed on the host computer using FORTRAN 77 and an applications library of microcode routines provided by Numerix.

OPERATIONAL MODES

The DDA is operated under menu-driven software control from the host computer. The DDA Executive software interfaces with 11 other major software modules to provide setup, calibration, on-line, and off-line operating modes as shown in Figure 3.

In the setup mode, the test parameter manager, data reduction constants manager, and bad probe substitution software are used to develop or modify the DDA database. The database defines parameter names, the sampling sequence and rate, filter cutoff frequencies, and data reduction constants required for a specific test configuration.

The calibration mode utilizes the calibration control software to perform a voltage substitution calibration of each input channel. This process validates the DDA measurement accuracy using a voltage standard that is traceable to the National Institute of Standards and Technology (NIST).

When operated in the on-line mode, the communications software provides for remote control of the DDA from the test unit's steady-state data system (See Fig. 1). These remote-control operations use the data acquisition, data control and processing, and data archival software to accomplish in-place pressure calibrations, acquisition of steady-state and transient data points, execution of distortion analysis algorithms, and data archival. A time line describing a typical sequence for acquisition and processing of a 60-sec data point is shown in Fig. 4. This sequence is initiated when the steady-state data system begins acquisition of steady-state data and commands the DDA to acquire dynamic data. After the steady-state data are acquired, converted to engineering units, and transferred to the DDA, the DDA begins processing while dynamic data are still being acquired. This parallel operation provides for execution of a typical distortion analysis algorithm for a 5000 sample/sec, 40-parameter configuration in less than three times real-time. For example, a 60-sec data point is processed in less than 180 sec after data acquisition is completed.

When processing is complete, results are available for review on the DDA graphic display. However, for on-line test support, results are normally transmitted back to the steady-state data system for display on graphic analysis workstations. This approach frees up the DDA for acquisition and processing of additional data without having to wait for analysis of previous data points to be completed.

The off-line mode uses the analog tape digitization and data analysis software to digitize distortion data reproduced from analog tape and provide the DDA user with tools for more detailed analysis of previously acquired data. Data digitized from analog tape may be processed and analyzed on the DDA and/or recorded on digital tape for processing on other analysis systems. Off-line data analysis features include contour, power

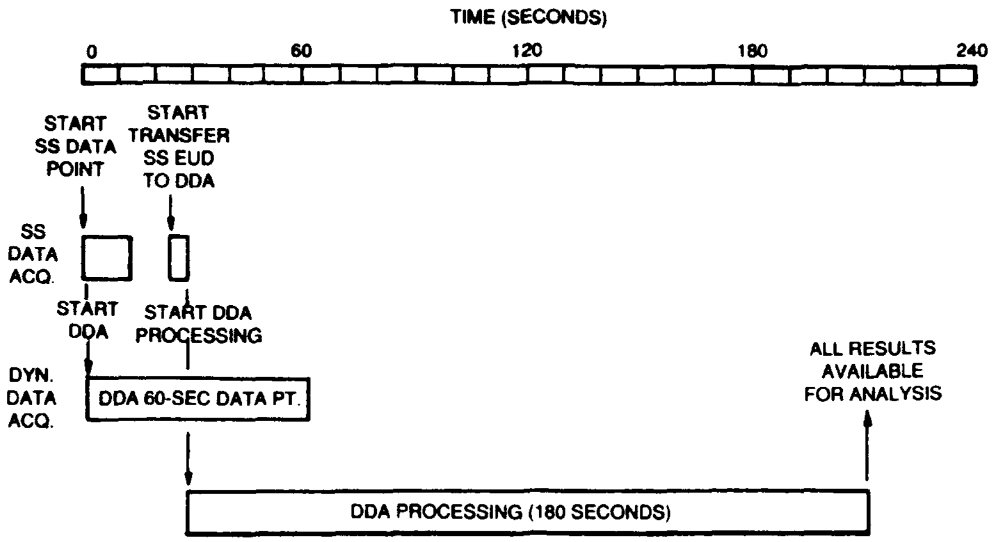


Fig. 4. DDA time line for typical 60-sec data point.

M	PT	P	Q	REX10-6	TT	TTR	H	PC	MC	WA	TPR	SHX10+3	TDP	DTDPS	PATM	PATMCL	PTINST
0.899	1041.3	616.2	348.8	2.004	108.6	568.3	30435.	624.4	0.8870	0.01	1.190	4.813	22.0	18.2	2043.0	2041.4	1042 4

DISTORTION MATRIX

	IDCMAX	IDRMAX	DPCPMX	DPCPAV	DPCPHP	ABPIPS
DELTIME	0 8912	2.7179	3.8309	3.2916	3.2916	3.1834
SCAN	3139.	9571.	13490.	11591.	11591.	11210.

IDCMAX	0.124
PEAK SCAN	3139.

	IDCMAX	IDRMAX	DPCPMX	DPCPAV	DPCPHP	ABPIPS	S/S	AVE	SIGD	SIGR
IDCMAX	0.124	0 114	0.114	0.108	0.108	0.066	0.062	0.072	0.013	4.2
IDRMAX	-0.024	-0.062	-0.014	-0.016	-0.016	0.010	0.014	0.016	0.006	7.1
DPCPMX	0.045	0.052	0.067	-0.064	-0.064	0.039	0.036	0.039	0.006	4.9
DPCPAV	0.040	0.047	0.052	0.055	0.055	0.033	0.030	0.039	0.005	4.7
DPCPHP	0.040	0.046	0.049	0.057	0.057	0.031	0.028	0.031	0.005	5.0
ABPIPS	0.004	0.003	0.003	0.004	0.004	0.027		0.003	0.002	10.4

TESTPOINT LOG AND CONDITIONS

				DURAT	5.000
				SCANS	17600
CONF	10	MACH	0.899	RATE	3521.0
XCS	48.25	PT0	7.23	RECSS	0.029
XPL	4.304	TTR	568.27	ABPIPS	0.004
		WCSFL		TURBAVE	0 018
				SUM40	0.002
				IRIG	9:56 7:5385

****** AIP INSTANTANEOUS TOTAL PRESSURE RATIOS AT PEAK (P/PT0) ******
****** AIP RMS RATIOS (RMS/PT2) ALL SCANS ******

	RKLOC	10	55	100	135	190	235	280	325 deg	
	RGLOC	RAKE 1	RAKE 2	RAKE 3	RAKE 4	RAKE 5	RAKE 6	RAKE 7	RAKE 8	RGAVG
RING1	316H	0.901	0 855	0.868	0.886	0.918	0.967	0.958	0.924	0.910
		0.021	0.022	0 021	0.019	0.019	0.019	0.020	0.019	
RING2	548	0.916	0.863	0.879	0.900	0.934	0.964	0.990	0.969	0.927
		0.018	0.022	0 021	0.019	0.016	0.013	0.015	0.020	
RING3	707	0.937	0.841	0 907	0.905	0.930	0.980	1.001	0.998	0.937
		0.018	0 021	0.020	0.019	0.015	0.013	0.011	0.017	
RING4	837	1.015	0.826	0.902	0.961	0.933	0.992	0.999	0.991	0.951
		0 026	0.021	0.019	0.021	0.017	0.011	0.010	0.000	
RING5	949T	0.947	0 930	0.904	0.945	0.919	0.956	0.994	1.000	0.937
		0.024	0.020	0.018	0 022	0.018	0 013	0.010	0.014	
INST	RKAVG	0.941	0 843	0 892	0 919	0.927	0.972	0.988	0.976	0.932

****** AIP STEADY-STATE PRESSURE RATIOS (PSS/PT0) ******
****** AIP BIAS RATIOS (BIAS/PT0) ALL SCANS ******

	RAKE 1	RAKE 2	RAKE 3	RAKE 4	RAKE 5	RAKE 6	RAKE 7	RAKE 8
RING1	0.896	0.896	0.902	0.905	0.923	0.942	0.947	0.916
	0.000	0.000	0.000	0.000	0.000	0.000	0 000	0.000
RING2	0.896	0.888	0.899	0.905	0.934	0.968	0.984	0.946
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RING3	0.917	0.884	0.896	0 910	0.937	0.984	0.995	0 976
	0.000	0.000	0.000	0.000	0.000	0.000	0 000	0.000
RING4	0.926	0.880	0.891	0.913	0.937	0.994	0.998	0.991
	0.000	0.000	0.000	0.000	0.000	0 000	0 000	0.000
RING5	0.908	0.874	0.879	0.893	0.901	0.949	0.988	0 991
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0 000

****** ARP1420 DESCRIPTORS AT PEAK ******

	DPC/P	PAVLOW	THEXT	MPR	Q	NREV	DPR/P
RING1	0 033	0 880	184.4	1.000	1.	1.	0.024
RING2	0.038	0.891	180.0	1.000	1.	1.	0.006
RING3	0.042	0.898	186 7	1.000	1.	1.	-0.005
RING4	0.048	0.905	156.7	1 000	2.	1.	-0.020
RING5	0.039	0.900	175.3	1.000	2.	1.	-0.005

DPRPH	0.024
DPRPT	-0 005
DPCPH	0.036
DPCPMH	0.040
DPCPMT	0.045
DPCPT	0.044

PROBE SUBSTITUTION

	DYNAMIC										STEADY-STATE									
BP	3.	18.	27.	39	0	0	0.	0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0	0.	0
S	2.	17.	28.	38.	0.	0.	0.	0.	0.	0.	0.	0	0.	0	0	0	0.	0.	0.	0
U	0.	0.	0.	0.	0.	0.	0.	0	0.	0	0.	0.	0.	0	0.	0.	0.	0.	0	0
B	0.	0.	0	0.	0.	0	0	0	0.	0.	0	0.	0.	0	0	0.	0.	0.	0	0
S	0.	0.	0	0.	0.	0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0	0	0.	0	0

TEN MAX SCANS OF THE PEAK PARAMETER

NO	DELTIME	SCAN	SIGR	IDCMAX	IDRMAX	DPCPMX	DPCPAV	DPCPHP	ABPIPS
1	0 8912	3139	4 2	0 124	-0.024	0 045	0.040	0.040	0.004
2	0.2354	830	4 1	-0 124	-0.020	-0.054	0.047	0 048	0.001
3	1.2891	4540	3 8	0 120	0 017	0.062	0.053	0.054	0.003
4	3 4236	12056.	3 8	0 119	-0.031	-0 042	0.039	0.039	0.005
5	4 7863	16854	3 7	0 119	-0.049	0 053	0.044	0.044	0.003
6	3.6838	12972.	3 7	0 119	-0.033	-0 049	0.041	0.041	0.005
7	3 8871	13688.	3 6	0 118	-0.021	-0.048	0.040	0.040	0.005
8	2 8213	9935	3 6	0 117	-0 044	0.049	0.039	0 037	0.001
9	1.2893	4541.	3 6	0 117	0 014	0 062	0.054	0.055	0 006
10	3 6858	12979	3.6	υ 117	-0.022	0.048	0 042	0 041	0.008

DPC/P

RING1	RING2	RING3	RING4	RING5
0 033	0.038	0 042	0 048	0 039
0 035	0.057	0.051	0.050	0.042
0.040	0 051	0.062	0.062	0.051
0.033	0.045	0 039	0 037	0.038
0 017	0.051	0.048	0 058	0.046
0.022	0 056	0.042	0 042	0 044
0 025	0.048	0.048	0.042	0.040
0.013	0 037	0.049	0 049	0.048
0.044	0.052	0.062	0 062	0.051
0.032	0.043	0 040	0 048	0.047

DPR/P

RING1	RING2	RING3	RING4	RING5
0.024	0 006	-0.005	-0 020	-0 005
0.020	0.000	-0.012	-0 011	0 002
0.013	-0.003	-0.011	-0.016	0 017
0.031	0.005	-0.005	-0 021	-0 010
0.049	0 005	-0.013	-0 027	-0 014
0.033	-0 003	-0.0*4	0 022	0 005
0.021	0 002	-0 011	-0 016	0 004
0.044	0.004	-0.014	-0.027	-0.007
0.014	-0.003	-0 011	-0 014	0 014
0.022	0 001	-0.009	-0 018	0 003

Fig. 5. Typical DDA distortion/data tabulation.

spectral density, time history, amplitude vs. frequency, histogram, and distortion index plots and tabulation of absolute and steady-state pressures, distortion indices, rms (root-mean-square) values, average pressures, and the distortion index matrix.

ANALYSIS CAPABILITIES

As described previously, the on-line test support data analysis capabilities of the DDA are provided by means of FORTRAN 77-coded algorithms that execute in the system's array processors. As an example, a typical DDA algorithm computes the basic distortion parameters for each scan in the data point at a rate of up to 10,000 scans/sec. As processing proceeds, selected distortion parameters are compared to identify the peak value for each parameter and the top 10 peak values of one particular parameter. The data scan number/time identifiers, computed distortion components, and pressure arrays associated with these peak values are saved and, upon completion of the data point, transmitted back to the test unit's steady-state data system for display and tabulation. A typical matrix of these peak values and other distortion parameters is shown in Fig. 5 for an aerodynamic interface plane (AIP) configuration consisting of 40 probes in an 8-rake/5-ring arrangement as shown in Fig. 6. In addition, these data and associated pressure arrays are transmitted to stand-alone graphic analysis workstations and the AEDC central computing facility where other types of tabulations and data plots are generated to meet specific test applications. Typical plotting capabilities that are presently programmed include time histories of pressures [1 ring (8 pressures) per page] and distortion indices; ring distortion (5 rings/page); contour plots of steady-state, peak, and rms pressure values; and histograms of distortion indices. Examples of these plots are shown in Figs. 7a-e. Other types of test-unique plots may be easily programmed.

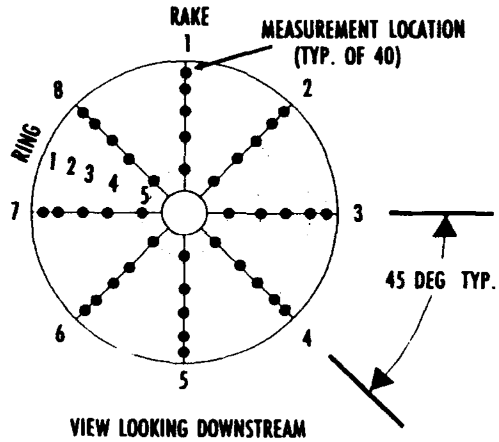
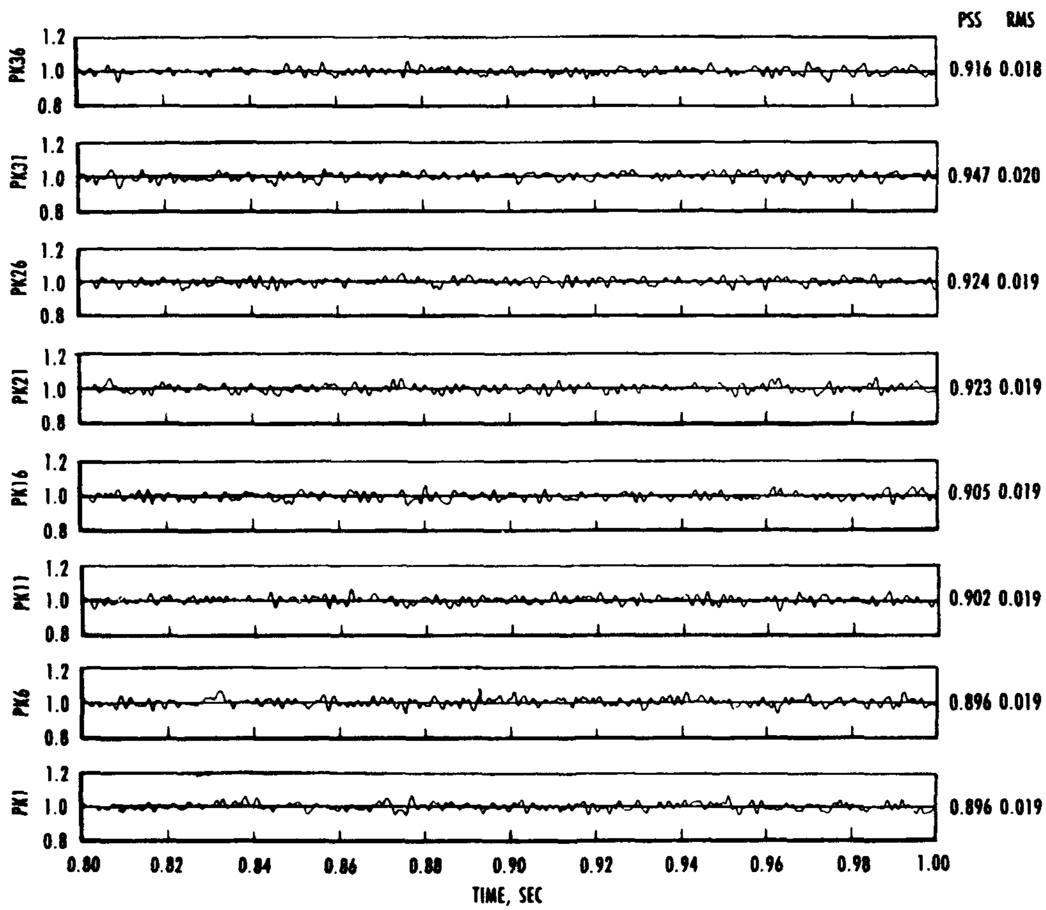
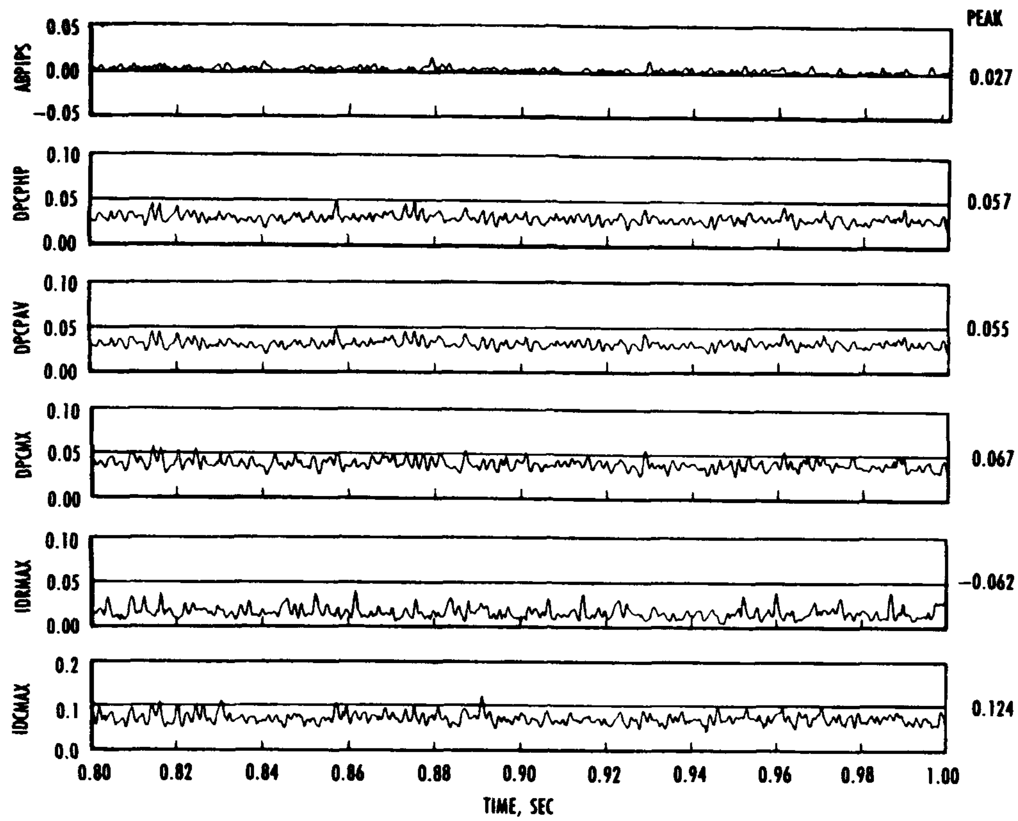


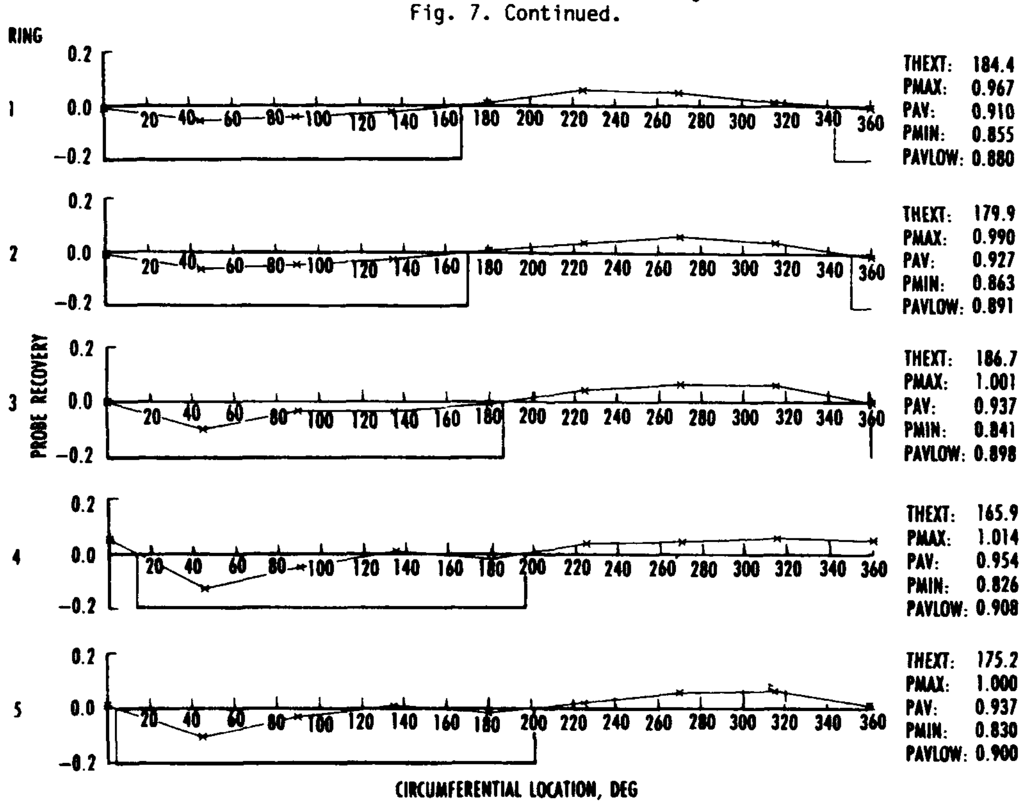
Fig. 6. Typical aerodynamic interface plane rake/ring arrangement.



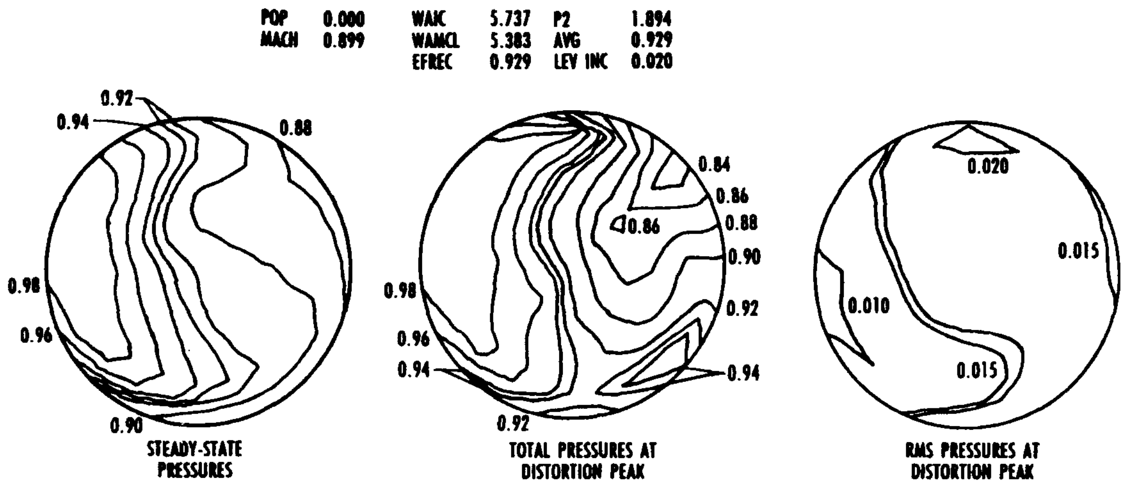
a. Ring pressure time history
Fig. 7. Test-unique plots.



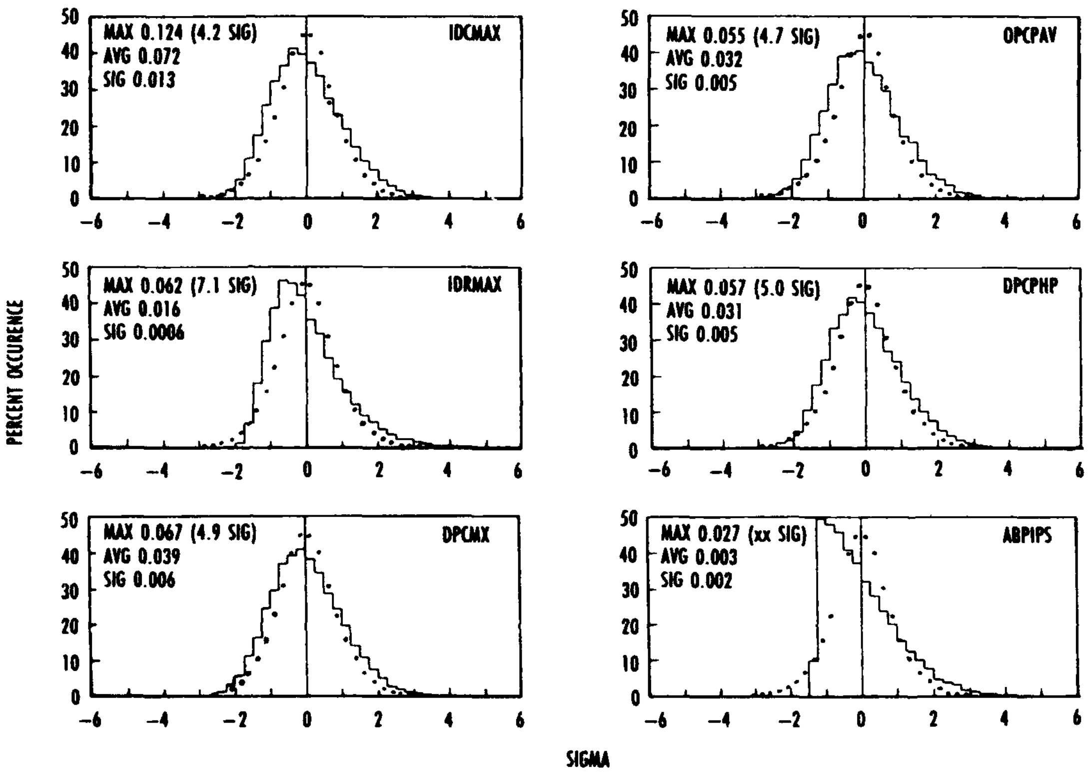
b. Distortion index time history
Fig. 7. Continued.



c. Ring distortion
Fig. 7. Continued.



d. Inlet contour maps
Fig. 7. Continued.



e. Distortion index histograms
Fig. 7. Concluded.

DDA RESULTS COMPARISON WITH PREVIOUS ANALYSIS TECHNIQUES

The first use of the DDA with 40-probe aerodynamic interface plane (AIP) configuration distortion data used the system's analog tape digitization capabilities to process seven data points from a free-jet technique validation test which was reported by Beale and Collier (1989). This test was conducted in an AEDC research test cell and used a 16-percent-scale free-jet nozzle and an F-15 inlet model. The data points processed by the DDA had been previously screened for peak dynamic distortion on the DYNADEC system, Wright-Patterson AFB, Ohio, which was configured to compute the Pratt and Whitney F100-PW-220 distortion analysis algorithm. The primary purpose for processing this data was to compare DDA and DYNADEC results while gaining experience in DDA setup and operation.

While the operational experience gained was beneficial, the maximum dynamic distortion time and amplitude values detected by the DDA and the DYNADEC could not be correlated. For example, the DDA's maximum values of distortion index KA2 were from 9 to 29 percent higher than those obtained by the DYNADEC. Additionally, the two systems did not locate the same peaks in any of the data points. The closest agreement was found in one set of data where two distortion index peaks of similar amplitude occurred approximately 130 msec apart. In this case, the DYNADEC apparently detected the first peak as the highest in the data point whereas the DDA flagged the second peak. A portion of the DDA KA2 time history plot for this data is shown in Fig. 8.

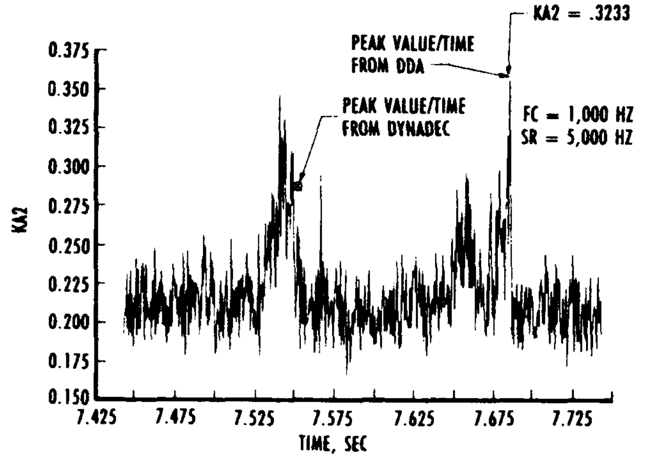


Fig. 8. DDA-DYNADEC comparison, 1,000 Hz bandwidth.

As a result of these differences, considerable time was spent in looking for possible errors on the DDA and analyzing differences in the methods used to process data on the DDA and the DYNADEC. In summary, no systematic errors were identified that would have caused the observed variations. However, when the bandwidth of the DDA was reduced by changing the input filter cutoff frequency from 1,000 to 200 Hz, the variations between the two systems were reduced significantly for this particular set of data as shown in Fig. 9. This seems to indicate that the DDA may have a higher internal bandwidth than the DYNADEC and is thus able to identify sharper distortion peaks that may be averaged out and reduced in amplitude by the DYNADEC. Since it was not possible to rerun other data points to verify this conclusion, additional comparisons are needed to better understand the differences in results obtained from the two systems.

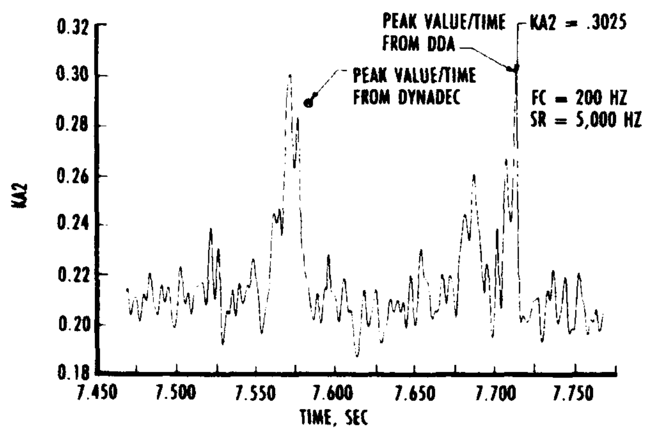
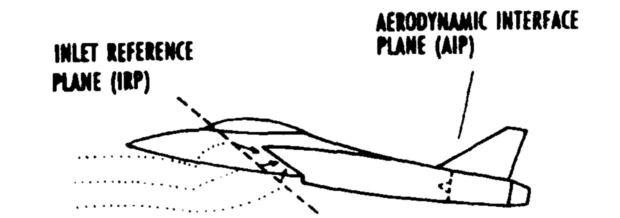


Fig. 9. DDA-DYNADEC comparison, 200 Hz bandwidth.

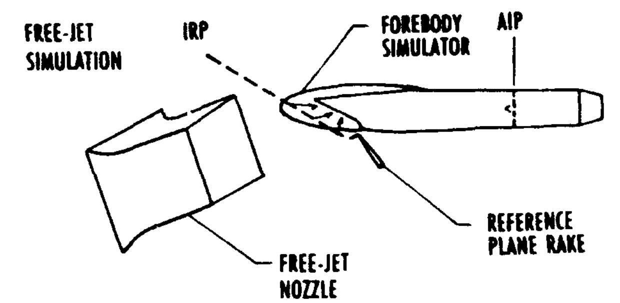
TEST SUPPORT APPLICATIONS

Although the DDA was designed to acquire and process time-dependent engine-face spatial total-pressure data in near-real-time, the very nature of that design provides the capability to acquire, process, and display other types of time-dependent data. In fact, initial DDA applications were not for inlet-engine distortion tests. For these tests, the DDA provided on-line digitization and recording of dynamic data for posttest analysis by means of the system's standard off-line data analysis software. As a result of the benefits gained from these initial uses of the DDA, many other AEDC applications including acoustic testing, dynamic stability testing (strain-gage/balance data), hot-wire anemometry, and weapons bay/stores testing are expected to use the DDA's general purpose data acquisition, recording, and analysis capabilities.

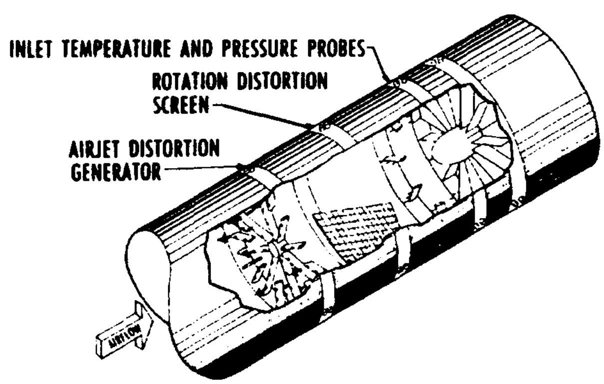
Additional applications are scheduled that will use the complete on-line distortion analysis capabilities of the DDA. These applications include full-forebody/inlet compatibility wind tunnel testing; free-jet limited forebody inlet-engine propulsion testing; and direct-connect (no forebody) distortion simulator propulsion testing. Schematic representations of these configurations are shown in Fig. 10.



Full forebody inlet compatibility test configuration



Free-jet/limited forebody propulsion test configuration



Distortion simulator/direct-connect configuration

Fig. 10. Typical AEDC inlet-engine distortion test configurations.

SUMMARY

The Digital Distortion Analyzer now provides AEDC with a state-of-the-art dynamic distortion analysis capability for on-line support of inlet-engine compatibility testing in the 16T/S wind tunnels and the C-1/-2 test cells. The system's FORTRAN 77-coded distortion analysis algorithms execute in high-speed array processors for near-real-time data availability and are readily modified to meet unique analysis requirements. In addition, the system's general purpose capabilities will be beneficial in providing on-line digital data acquisition, quick-look data analysis, and posttest digitization of analog tape data in support of many other types of aerodynamic and propulsion tests.

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