NASA/TM-2000-209858

Flight Test Measurements From The Tu-144LL Structure/Cabin Noise Experiment

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January 2000

Available from the following:

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Abstract

During the period September 1997 to February 1998, the Tupolev 144 Supersonic Flying Laboratory was used to obtain data for the purpose of enlarging the data base used by models for the prediction of cabin noise in supersonic passenger airplanes. Measured were: turbulent boundary layer pressure fluctuations on the fuselage in seven instrumented window blanks distributed over the length of the fuselage; structural response with accelerometers on skin panels close to those window blanks; interior noise with microphones at the same fuselage bay stations as those window blanks. Flight test points were chosen to cover much of the TU-144's flight envelope, as well as to obtain as large a unit Reynolds number range as possible at various Mach numbers: takeoff, landing, six subsonic cruise conditions, and eleven supersonic conditions up to Mach 2. Engine runups and reverberation times were measured with a stationary aircraft. The data in the form of time histories of the acoustic signals, together with auxiliary data and basic MATLAB processing modules, are available on CD-R disks.

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1. Introduction

1.1. Tu-144 Program Overview

The Tu-144 modification and flight research program was initiated in September 1994 as part of the NASA High Speed Research (HSR) program. The overall objectives of the program were to modify and make flight worthy a Russian Tu-144 supersonic transport aircraft as a flight research test bed and conduct flight experiments to generate useful data for the HSR program [1]. The original program consisted of three phases:

Phase I: Aircraft Modification/Refurbishment

An out-of-service Tu-144 supersonic transport aircraft was completely refurbished and re-fitted with Kuznetsov NK-321 engines. This phase of the program culminated in the first flight of the modified and refurbished aircraft on 29 November 1996. A photograph of the resulting aircraft, designed the Tu-144LL supersonic flying laboratory, is shown in Figure 1. Elevation, planform and front-view drawings of the aircraft are provided in Appendix A.

Phase II: Flight Test Planning and Preparations

Development of plans for six selected experiments and installation of instrumentation and data acquisition systems on the test aircraft for the experiments was conducted under this phase.

Phase III: Conduct of Flight Tests

This phase was to establish the airworthiness of the modified test aircraft over the entire flight envelope, acquire data for the flight experiments, reduce the data to engineering units and evaluate data quality. Nineteen flights were conducted over the period November 1996 to March 1998. References [1-7] summarize the six experiments. This phase ended in May 1998.

Phase IV: Follow-On Program

Following the successful completion of the original three phases, a fourth follow-on phase was initiated. This phase consisted of seven experiments. Eight flights (20-27) were performed during the period September 1998 to April 1999. References [8-15] summarize the seven experiments. This phase ended in June 1999.

1.2. Structure/Cabin Noise Experiment 2.1

The data described in this report were collected as part of phase III of the program. A companion report describes the data acquired during the phase IV follow-on program [16]. Coordination of U.S. team activities was performed jointly by Robert G. Rackl and Stephen A. Rizzi. Coordination of Russian team activities was performed by Eduard V. Andrianov.

The objectives of this project were formulated in 1994, in coordination with HSR Structural Acoustics ITD team members, and modified during negotiations with Tupolev in Moscow, Russia, in September of that year. These were:

- Add cabin noise prediction abilities to the design database for supersonic passenger aircraft by measuring turbulent boundary layer fluctuating pressure levels on the fuselage and acoustic loads due to engine exhaust flow. Also determine fuselage structural response, and interior noise levels.
- In the short run, use the data for validating boundary layer [17] and jet noise source models and models of the interaction of boundary layer flow and fuselage skin structure [18].

- In the longer run, the data may serve to improve models of noise transmission into interior fuselage spaces under supersonic boundary layer exterior excitation.

An experiment plan containing measurement locations and techniques, instrumentation specifications, and flight test conditions, was developed by the experiment 2.1 U.S. team to accomplish these objectives. The experiment 2.1 U.S. team consisted of representatives from NASA Langley Research Center (LaRC), Boeing and McDonnell Douglas. The plan was presented by the U.S. team coordinators to V. Sablev of Tupolev at the NASA Dryden Flight Research Center (DFRC) in February 1995. The functional instrumentation system was reviewed and demonstrated for Messrs. Sablev and Andrianov at the NASA LaRC in November 1995.

As done on previous occasions [19, 20], turbulent boundary layer fluctuating pressure levels were measured using dynamic pressure transducers flush mounted into metal blanks that replaced windows on the right (starboard) side of the aircraft. For validation of flow/structure interaction models the correlation lengths in the downstream and cross-stream directions are required. An attempt was made to cover as large a range of correlation lengths as feasible by placing transducers within centimeters of each other, as well as two fuselage frame bays apart (that is also the distance between adjacent windows). Furthermore, Tupolev agreed to pierce the fuselage skin in two places between windows in order to place transducers half way between windows in an effort to further increase the resolution of the correlation length scales for the lower frequencies in the turbulence. At adjacent locations on the skin, the structural response due to the turbulent boundary layer pressure fluctuations was measured with accelerometers.

The interior acoustic field was measured with standard microphones. Interior microphones were placed generally on the left (port) side of the cabin at a seated passenger's head height. The microphone locations were nominally at the same body stations as the window blank locations, with the exception of the two furthest aft microphones in the rear cabin. These were relocated to the instrumentation compartment in the tail section because of high noise levels in the aft rear cabin produced by special on-board equipment. The passenger cabin microphones were oriented pointing up for locations away from a wall, and pointing at the wall when close to a wall. A microphone was also mounted in the flight deck on the pilot's seat at head height

Two on-ground measurements were performed as well:

- Engine runups with a stationary aircraft in order to assess the jet noise component by itself.
- Reverberation times at interior microphone locations in order to assess the interior space acoustic absorption characteristics

Simultaneously with this acquisition of data, Tupolev obtained measurements of sonic fatigue loads on engine inlet, rear fuselage, and flight control surface structural components using a separate recording system. This effort is documented in reference [21].

Data was acquired on six research flights of the Tu-144LL during the period September 1997 to February 1998. All flights were conducted out of Zhukovsky Air Base near Moscow, Russia. Instrumentation installation was performed jointly by U.S. team members and Tupolev personnel. Further, data acquisition required the presence of U.S. team members before and after most test flights. Besides the authors, the following individuals of the NASA LaRC also supported the installation and flight tests: Keith Harris, Donna Gallaher, and Vernie Knight.

Figure 1: Photograph of the Tu-144LL Supersonic Flying Laboratory.

2. Instrumentation

2.1. On-Board Instrumentation

2.1.1. Window Blanks

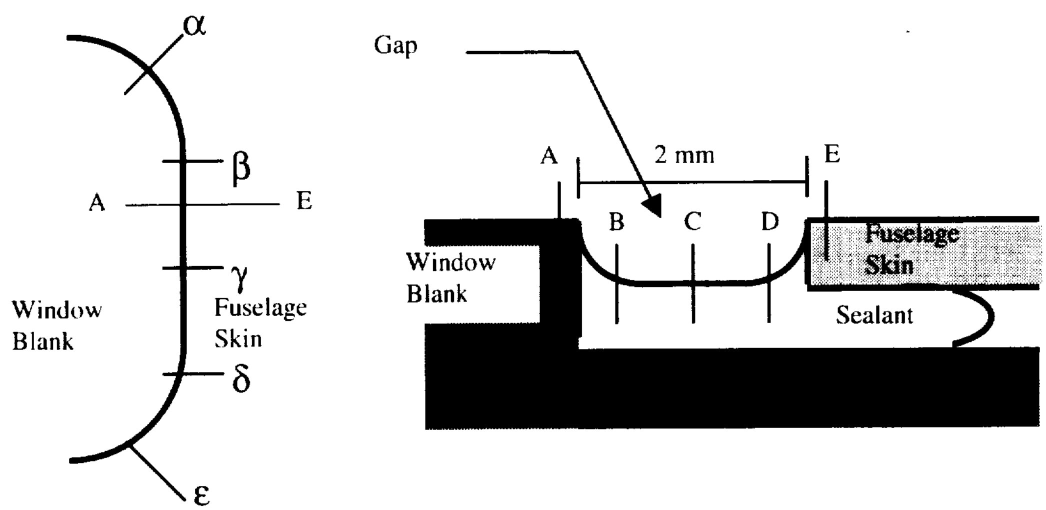
The seven window blanks were designed and produced by Tupolev based on the measurement locations in each specified by the U.S. team. They are slightly curved to conform with the fuselage outer diameter. Figure 2 shows the location and identification of window blanks, mounted on the right (starboard) side of the aircraft. Window blanks 3, 4 and 5 were chosen next to each other in order to provide the above mentioned correlation lengths. Figure 3 shows an excerpt from a Tupolev drawing for window blank number 4 which contains the largest number (9) of mounting holes for pressure transducers among the seven window blanks. The approximate distances of the window blank centers and of the two transducers mounted directly into the fuselage skin (S1 and S2) are given in Table 1. The distances are not highly accurate because they were obtained from a 1/50 scale drawing which was a little distorted; they should be sufficiently accurate for estimating boundary layer thickness (see Section 5.7).

Table 1: Approximate distances of window blanks from aircraft nose (including nose boom).

	Distance from Nose (including nose boom)	
	meters (±0.5)	feet(±1.5)
Nose (without nose boom)	0.9	3
Window Blank 1	18.9	62
Window Blank 2	25.9	85
Window Blank 3	31.2	102
S1	32.1	105
Window Blank 4	32.6	107
S2	33	108
Window Blank 5	33.5	110
Window Blank 6	43.2	142
Window Blank 7	49.3	162

There was a gap between the window blanks and the fuselage skin which was irregularly filled with a gasket sealant and with paint (the window blanks were painted together with the whole fuselage before transducer installation). Because of concerns over the effects of the gap on boundary layer turbulence development, attempts were made to fill this gap with a material that adhered to the metal and the gasket, and survived the temperatures at supersonic speeds. Data on typical gap dimensions before and after the filling attempt follow in Table 2 and Table 3, respectively.

Table 2: Window blank gap survey (before filling).



Window Blank	Station	Cross-sectional Position (all measurements are relative to A)			
		B	C	D	E
7	α	730	800	100	-50
(rear-	β	-20	-60	-40	-200
most	γ	50	250	200	100
window	δ	50	200	110	10
blank)	ε	100	260	300	70
6	α	40	260	130	-150
	β	-100	-150	-200	-360
	γ	-30	-170	-110	-280
	δ	0	15	-100	-300
	ε	-40	-180	-110	-225

(Measurements given in thousandths of a millimeter, valleys positive, hills negative)

These measurements are meant to convey a feel for the unevenness of the fill between the window blanks and the surrounding fuselage skin. These two window blanks are typical of all window blank installations. Only the upstream portion of the gap was surveyed. Measurements were made difficult by the softness of the gasket material in the gap which distorted when applying the depth gauge, and also due to cold weather (the airplane was stored in an open hangar previously used for an airship). The filling took place between flights 9 and 10.

Table 3: Window blank gap survey (after filling).[1]

Window Blank	Station	Cross-sectional Position (all measurements are relative to A)			
		B	C	D	E
1	α	20	40	400	100
	β	-40			-600
	γ	6	300	700	40
	δ				-5
	ε				110
2	α	80	300	300	320
	β	0	30	200	100
	γ	20	20	50	120
	δ	40	100	0	-30
	ε	30	200	150	100
3	α				
	β				
	γ	200	250	200	30
	δ				
	ε				
4	α	27	-50	20	11
	β	-100	-400	-120	-300
	γ	20	90	170	40
	δ	-30	90	-60	-170
	ε	400	100	100	70
5	α	250	190	120	110
	β	20	100	250	0
	γ	30	100	200	150
	δ	-30	30	100	-200
	ε	80	200	300	-55

[1] Missing data could not be measured either because of obstacles on the window blank (e.g., transducer cover), or because the weather was too cold to hold instrument properly.

Window Blank	Station	Cross-sectional Position (all measurements are relative to A)			
		B	C	D	E
6	α	-20	100	20	-180
	β	-20	-20	-100	-300
	γ	-20	-150	-300	-500
	δ	-20	-120	-250	-330
	ε	-85	-80	-30	-250
7 (rear-most window blank)	α	-20	50	17	-160
	β	40	90	-150	-250
	γ	200	200	150	80
	δ	130	300	160	12
	ε	80	100	30	50

(Measurements given in thousandths of a millimeter; valleys positive, hills negative; see Table 2).

The filling compound was hard to handle. Tupolev personnel reported that many applications or layers were required. It adhered well to the metal and paint, but it stayed soft even after curing so that it was not possible to sand it. Overall, the gap was not as pronounced as before the filling, but it still provided a significant source of roughness. The last column in the above table shows the size of the step from the fuselage skin to the window blank.

Several of the window blanks also carried instrumentation associated with experiment 3.3 "Cp, Cf and Boundary Layer Measurements, " [7]. These were window blanks 1, 2, 5 and 6. Window blank 1 had a static pressure port (nominally the size of a Kulite) located in the upper-aft corner of the window blank, i.e. aft of Kulite N1.2 and above N1.3. Window blanks 2, 5 and 6 each had a flush-mounted skin friction gage approximately 2-in. in diameter located in the lower-aft corner of each window blank. Flushness measurements of the skin friction gages were not made due to the sensitive nature of their sensing surface. A static pressure port was also located in the upper-aft corner of each of those window blanks.

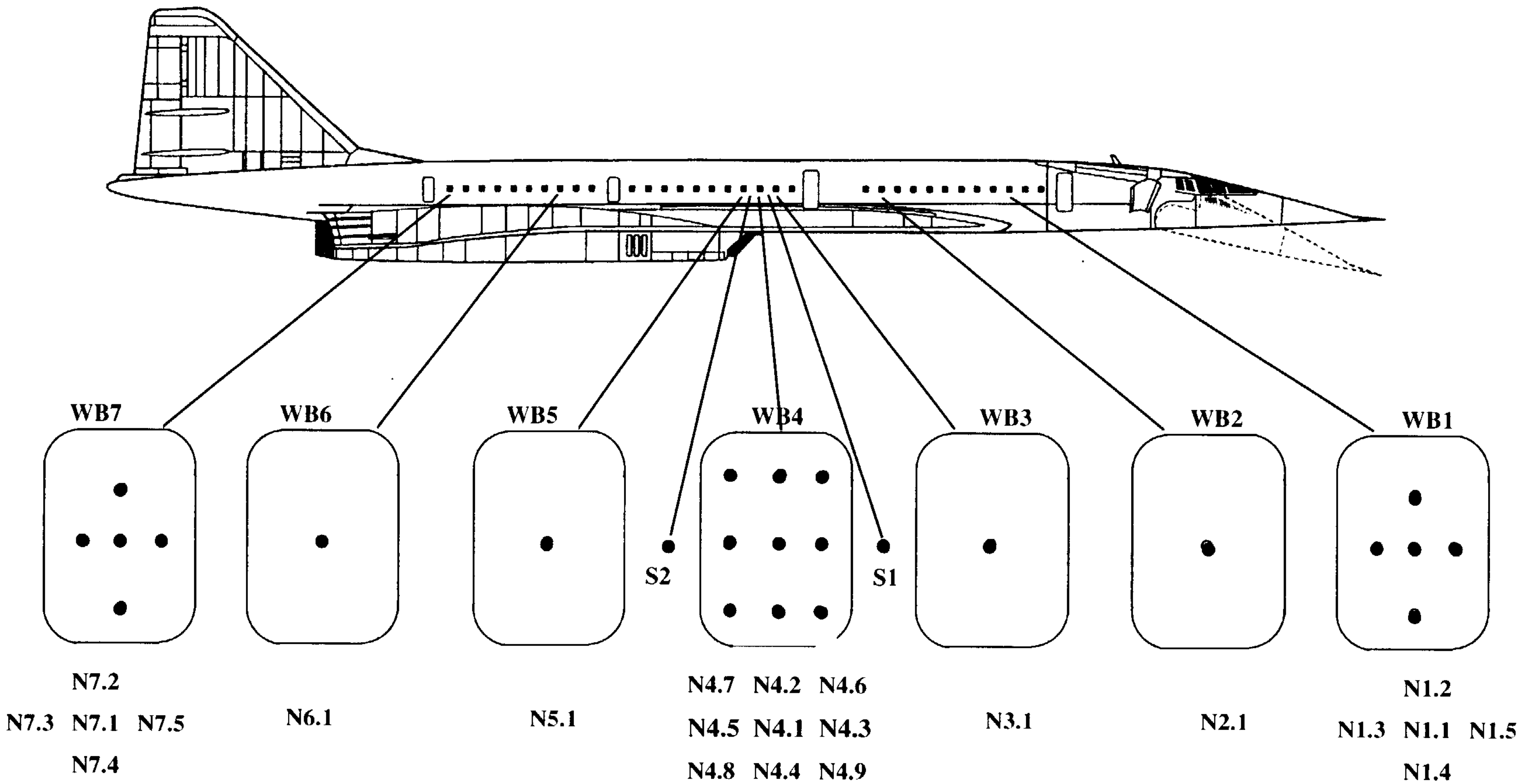


Figure 2: Location and identification of window blanks (WB) instrumented with Kulite pressure transducers (N1.1 – N7.5, S1, S2).

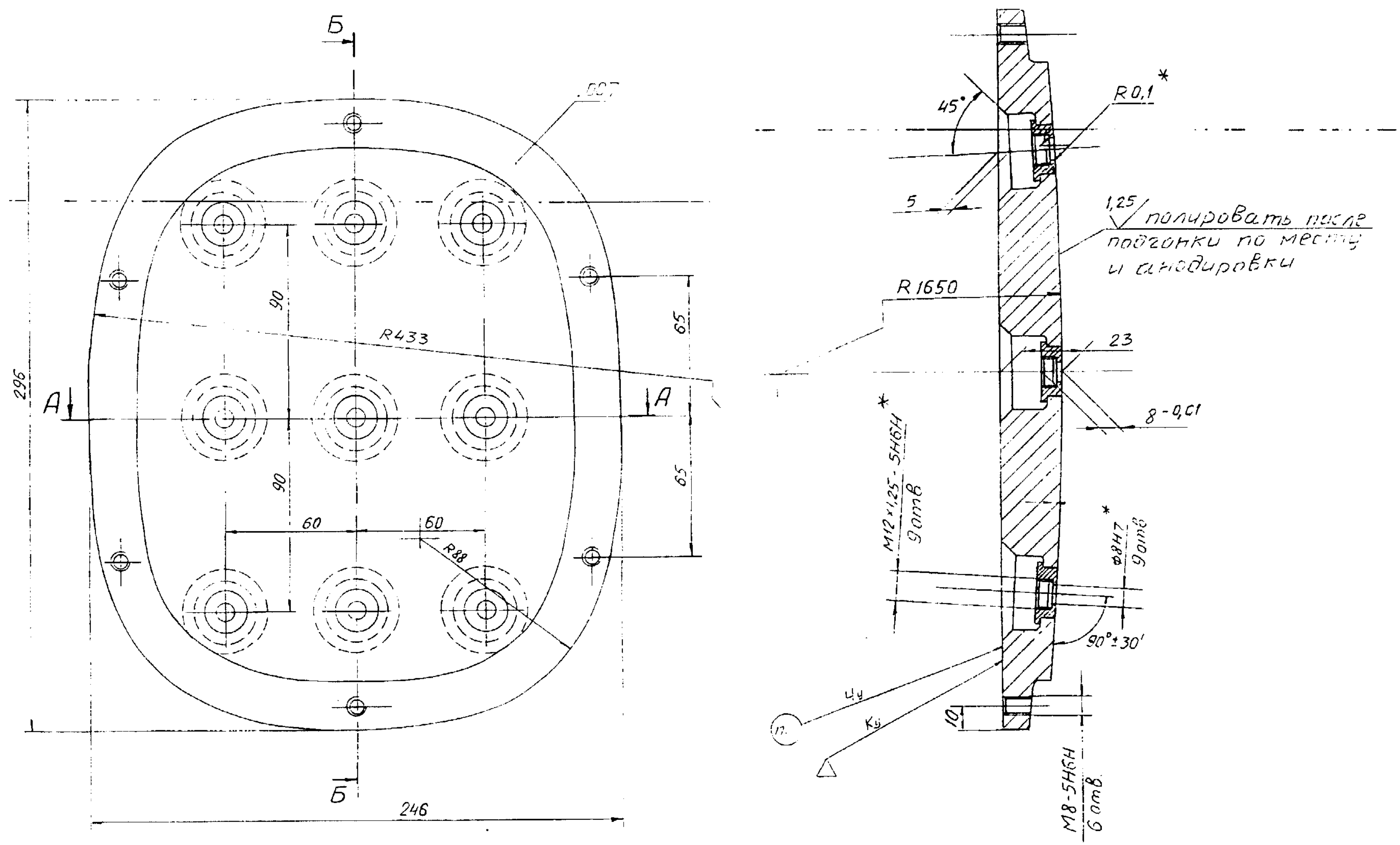


Figure 3: Excerpt from a Tupolev drawing for window blank number 4.

2.1.2. Transducers.

2.1.2.1 Dynamic Pressure Transducers

There were 25 dynamic pressure transducers; 23 were distributed over seven window blanks, and two were mounted directly into the side wall between window blanks 3, 4, and 5 (see Figure 2, Figure 4, and Figure 5). The transducers were manufactured by Kulite Semiconductor Products, Inc; all 25 were the same model: XCS-190-15D, with the following options:

- 0.750 inch long thread length, with metric thread M5x0.5-6g
- 1 inch long reference tube
- "B" screen (transducer face consists of a circular plate perforated with a circle of holes)
- 10 feet long 32 gage Shielded cable
- Internal temperature compensation
- Temperature compensation range -20 to +350 °F
- Coated diaphragm
- Case isolated from shield
- Differential operational mode

A copy of the specification sheet is found in Figure 47 of Appendix B.

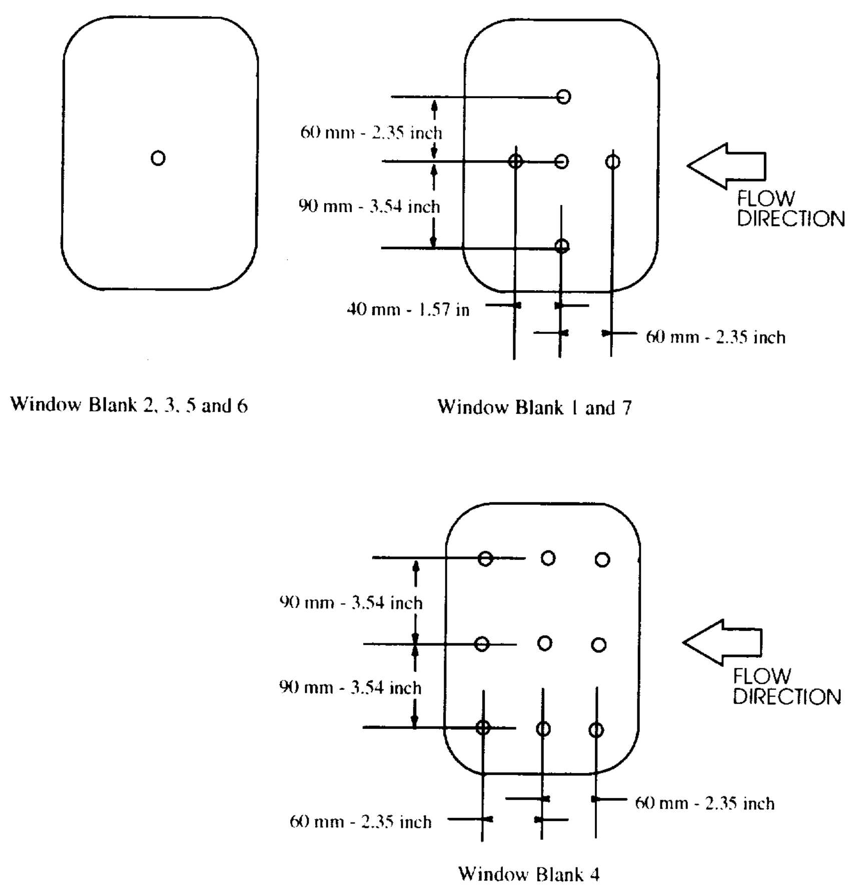
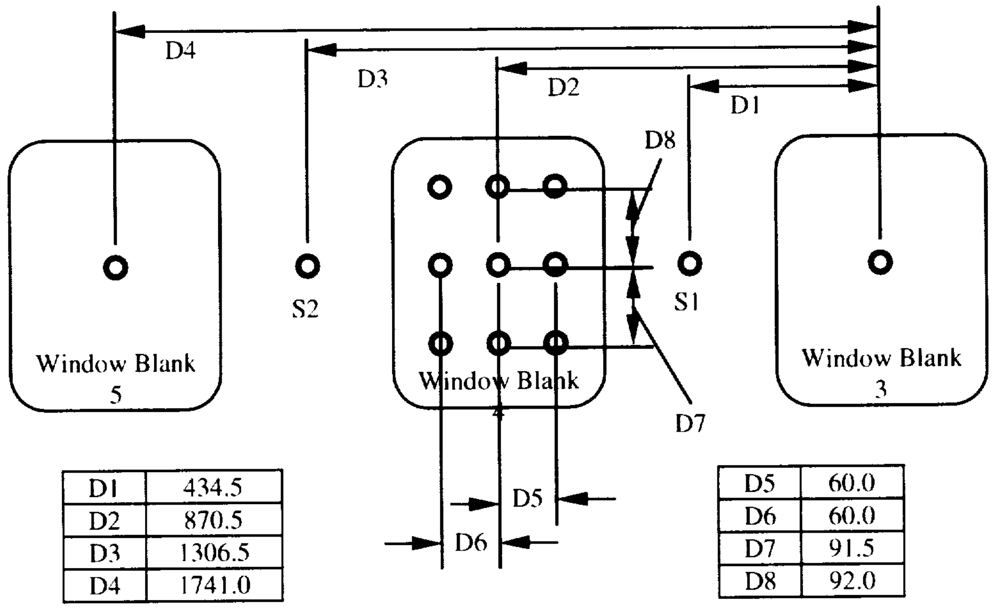


Figure 4: Arrangement of dynamic pressure transducers in window blanks.



D1	434.5
D2	870.5
D3	1306.5
D4	1741.0

D5	60.0
D6	60.0
D7	91.5
D8	92.0

Figure 5: Transducer arrangement and actual dimensions (mm) for window blanks 3, 4, and 5.

Figure 6 shows a photograph of a bare transducer together with one in its insulating/mounting boss. The thin reference tube in the back of the transducer vented to the aircraft interior. On a majority of the transducers, these were ordered bent to avoid interference of the tube with fuselage side wall insulation materials upon installation.

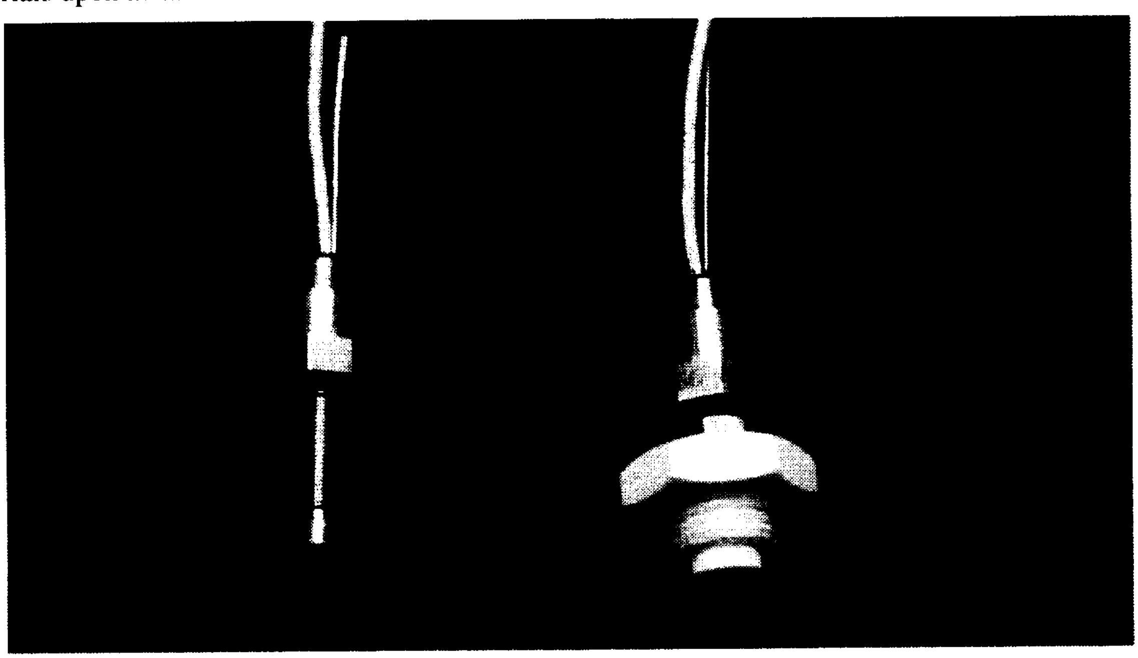


Figure 6: Photograph of Kulite transducer and its insulating/mounting boss.

Previous experience with airplane window blank mounted pressure transducers indicated that the transducer should be mounted electrically isolated in order to reduce electrical noise. A plastic boss was designed as shown in Figure 7. The boss was fabricated from a polymer having the trade name "Techtron PPS," sold by The Polymer Corporation. This material was chosen for its excellent machinability, electrical insulation, and high operating temperature (425 °F) characteristics. All 25 Kulite transducers were mounted using this arrangement. The thread with the finest pitch made available by the Kulite provider was chosen in order to make the adjustment of the transducer face's evenness ('flushness') with the outer surface as finely controllable as possible. The 12 mm thread between the boss and the window blank was secured with a small amount of Glyptol (a special purpose red paint). A small amount of Glyptol was also used between the outer hexagon of the lock nut and the insulating boss (see also Figure 8).

Interior and exterior views of the Kulite installation in window blank 7 are shown in Figure 8 and Figure 9, respectively. Figure 10 shows an exterior view of window blank 4, with close-up views of Kulite transducers N4.2 and N4.6 in Figure 11 and of Kulite N4.3 in Figure 12. The latter two figures also give a feel for the typical quality of the sealant between the window blank and fuselage skin. Finally, Figure 13 shows the installation of Kulite S2. For Kulite transducers S1 and S2, a small disk (into which the Kulite was mounted) was screwed into a reinforcing plate riveted to the fuselage interior. Thus, the quality of the installation was not as good as the installation of transducers in window blanks.

From previous experience, it was known that a 'flush' transducer installation with the outer surface was critical. Because this transducer's sensitive element is located behind a protective screen, it was not know at first to what degree of 'flushness' this transducer should be installed. The Boeing Company contracted with TsAGI (Central Aerohydrodynamic Institute in Moscow, Russia) to investigate this matter [22]. The principal investigator was Professor Boris Efimtsov who used a small supersonic wind tunnel with the transducer mounted in the tunnel wall using the above mentioned insulating boss (see also Section 6.2). Prof. Efimtsov investigated transducer apparent sensitivity and static pressure offsets as a function of frequency and tunnel flow Mach number, varying the amount that the transducer face protruded past the surrounding surface, or was recessed into it. Protrusion or recess was measured very carefully using optical methods. The resulting recommendations were:

- Install the transducer as flush as possible; try to ensure flushness within a few thousandths of a millimeter.
- If exact flushness cannot be obtained, recess as much of the transducer face as necessary so that no part of it protrudes.

Several actions were taken to try to follow these recommendations:

- The transducer faces were found to be quite uneven in the light of the above stringent requirements. They were carefully sanded to be as flat as possible without compromising the strength of the connection between the protecting grid and the transducer body. It was not possible to make them as flat as required to achieve the flushness recommended above.
- A mechanical depth gage accurate to better than a thousandths of a millimeter was used during installation of the transducers. The feeling end (tip) of the depth gage consisted of a sphere, roughly 3 mm in diameter. After optimizing each transducer's depth setting, a map of depths was produced; results appear below. The desired extremely tight tolerance on flushness could not be obtained.

Flushness measurements were made at a number of points as indicated in Figure 14. Points A, G, F, and M are located on the window blank (or fuselage skin for transducers S1 and S2). Points Ref, H, E, and L are located on the insulating boss. Points B, J, D, K, and C were located on the Kulite transducer face or protecting grid. Measurement results are presented in Table 4. Most points were within twenty-thousandths of a millimeter. A notable exception is transducer S2 whose installation was considerably rougher than the others, as shown in Figure 13.

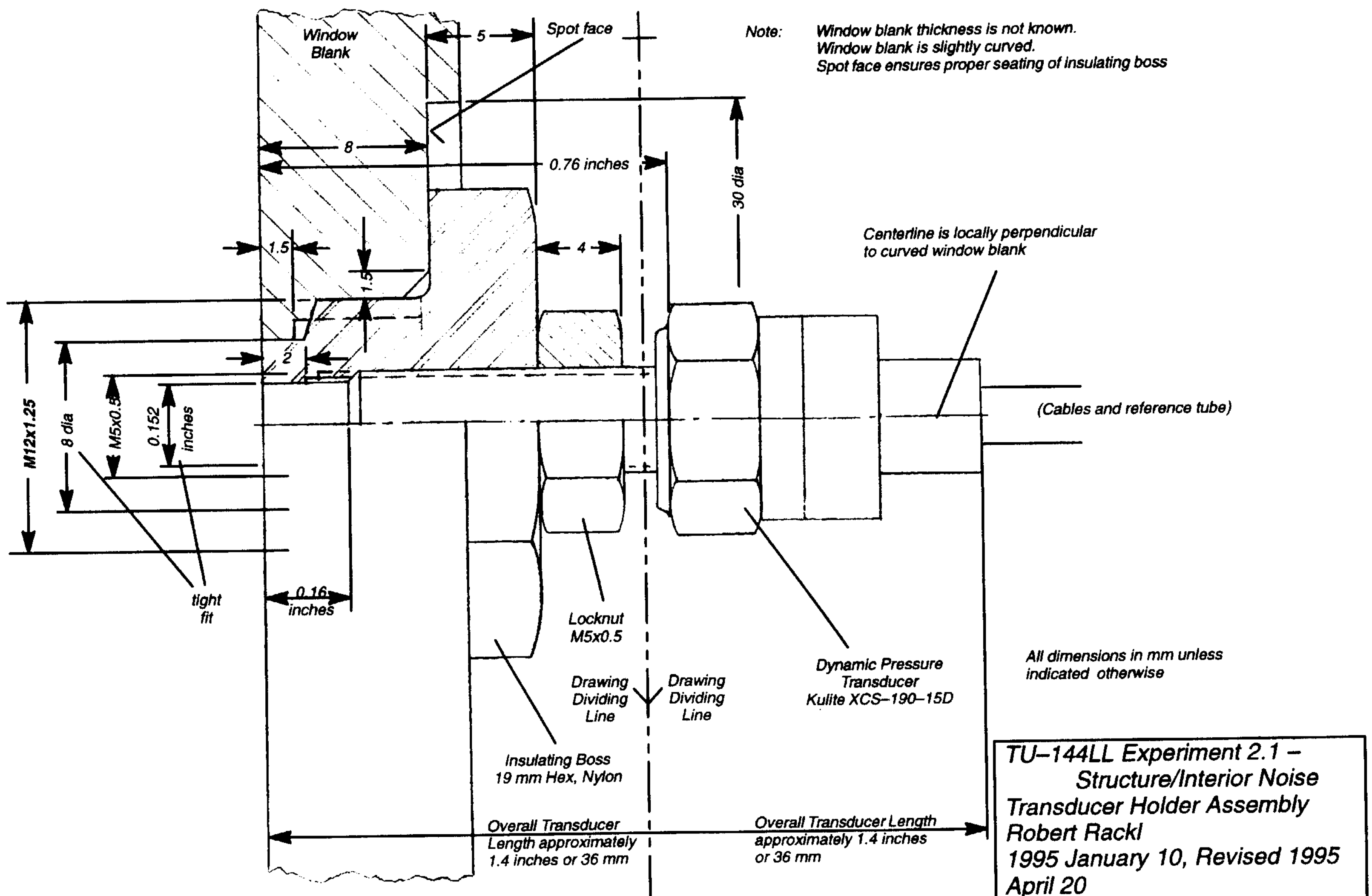


Figure 7: Drawing of Kulite transducer insulating/mounting boss.

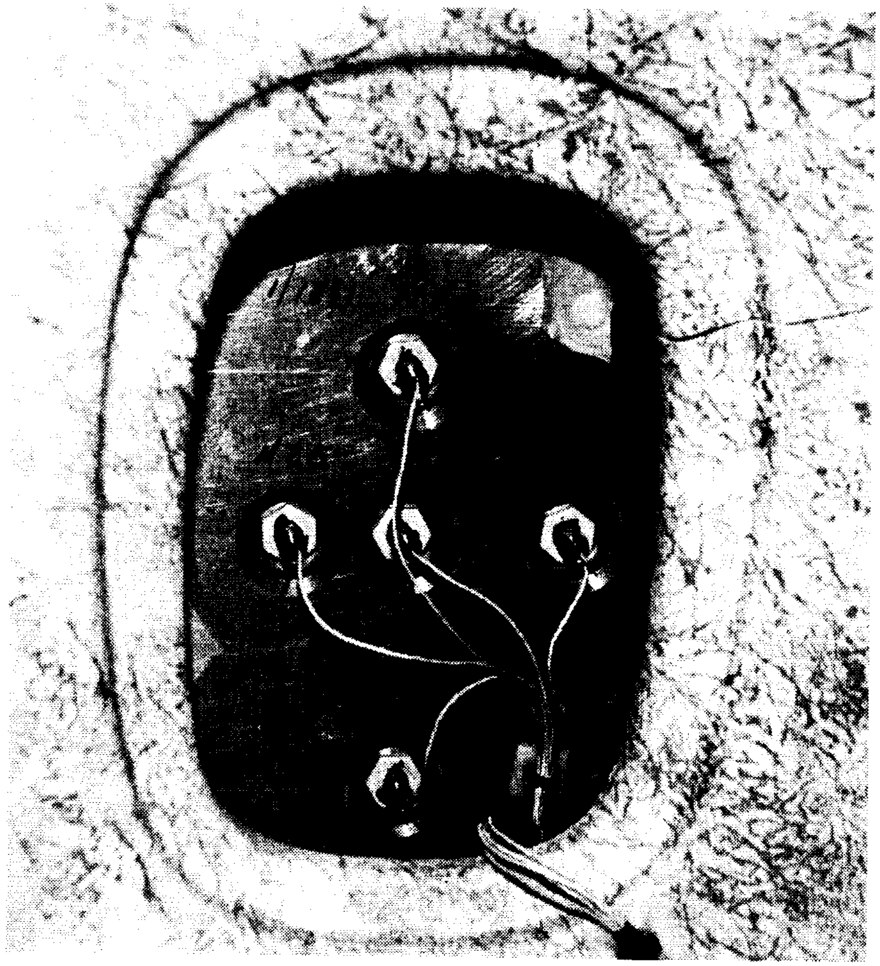


Figure 8: Photograph of interior side of window blank 7 with Kulite transducers installed.

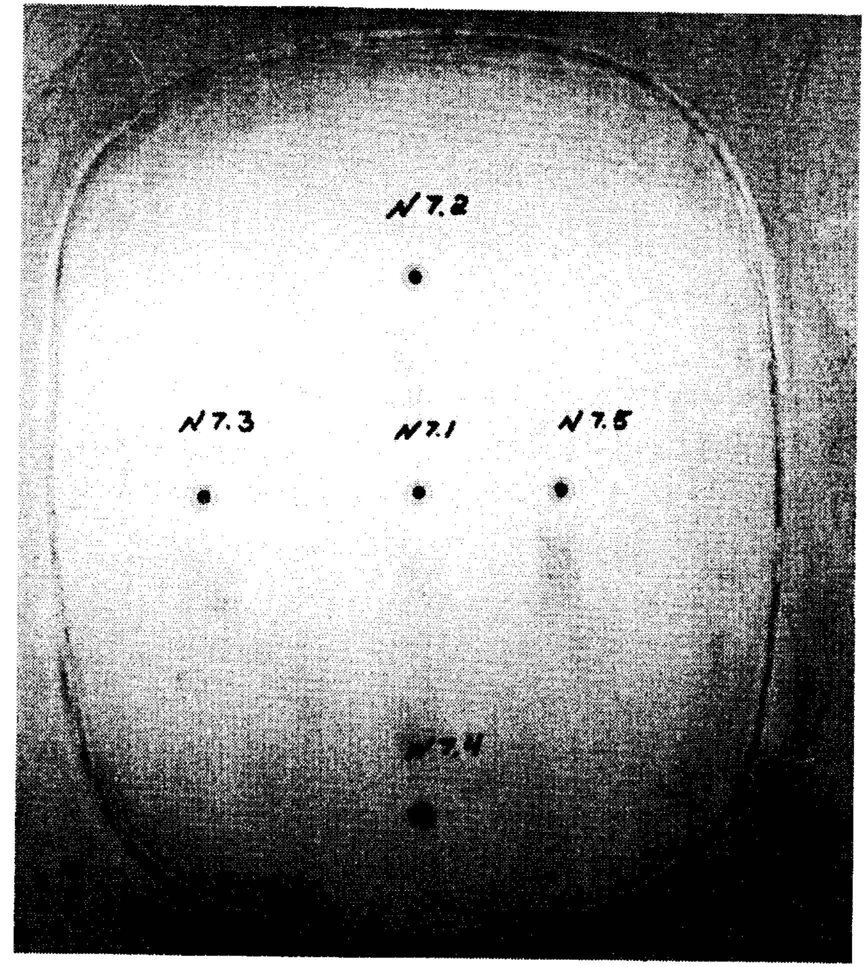


Figure 9: Photograph of exterior of window blank 7 with Kulite transducers installed.

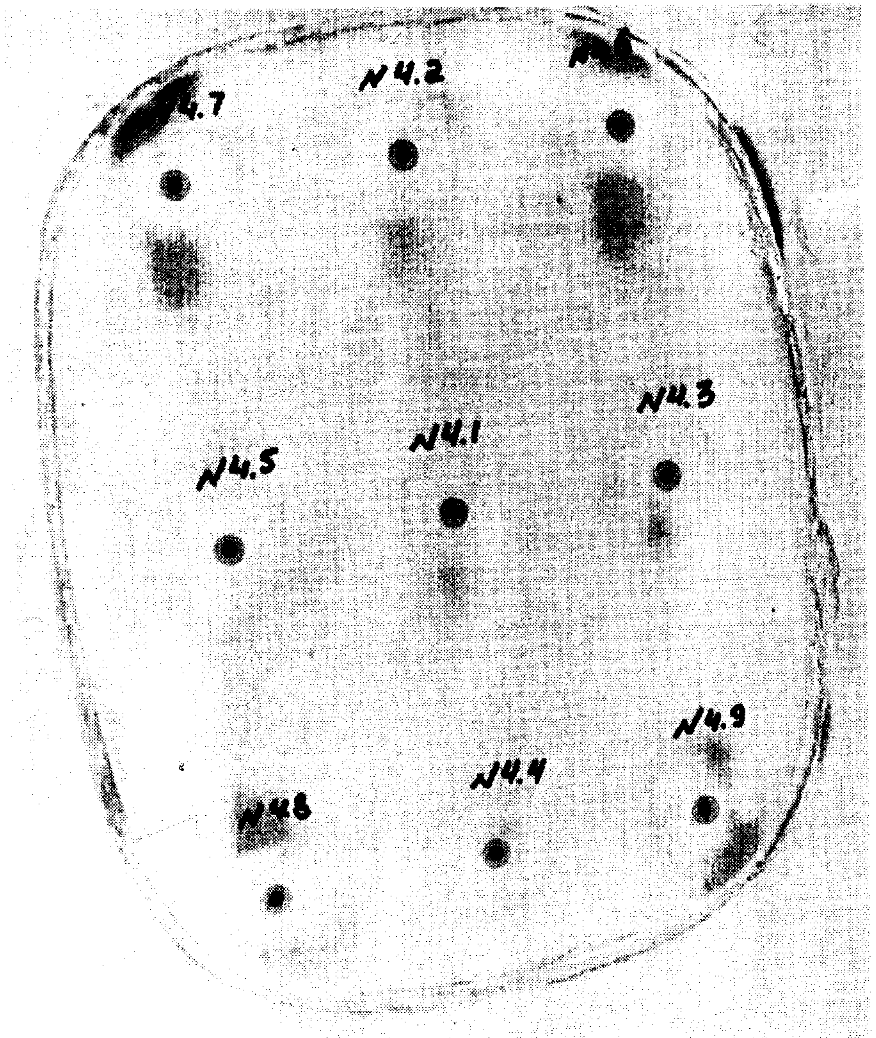


Figure 10: Photograph of exterior of window blank 4 with Kulite transducers installed.

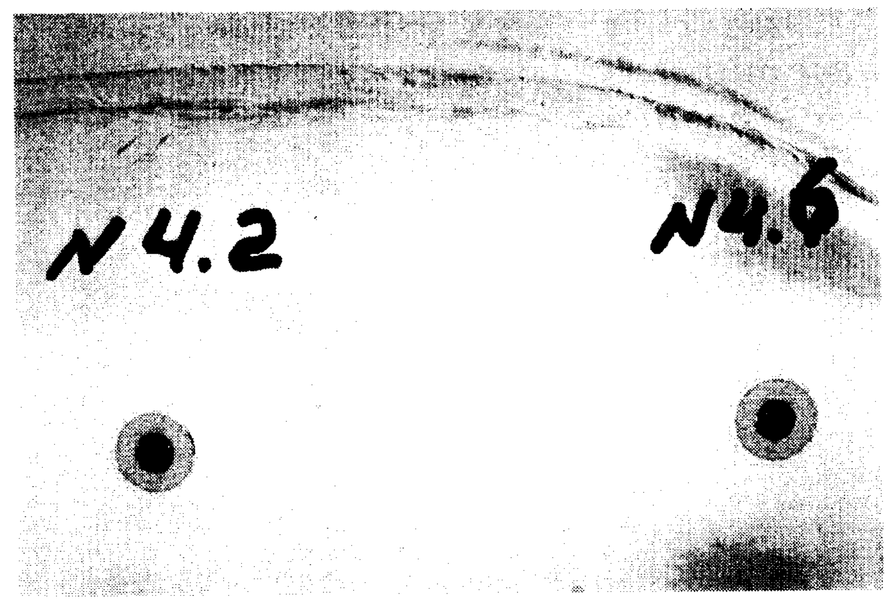


Figure 11: Exterior close-up photograph of Kulite transducers N4.2 and N4.6.

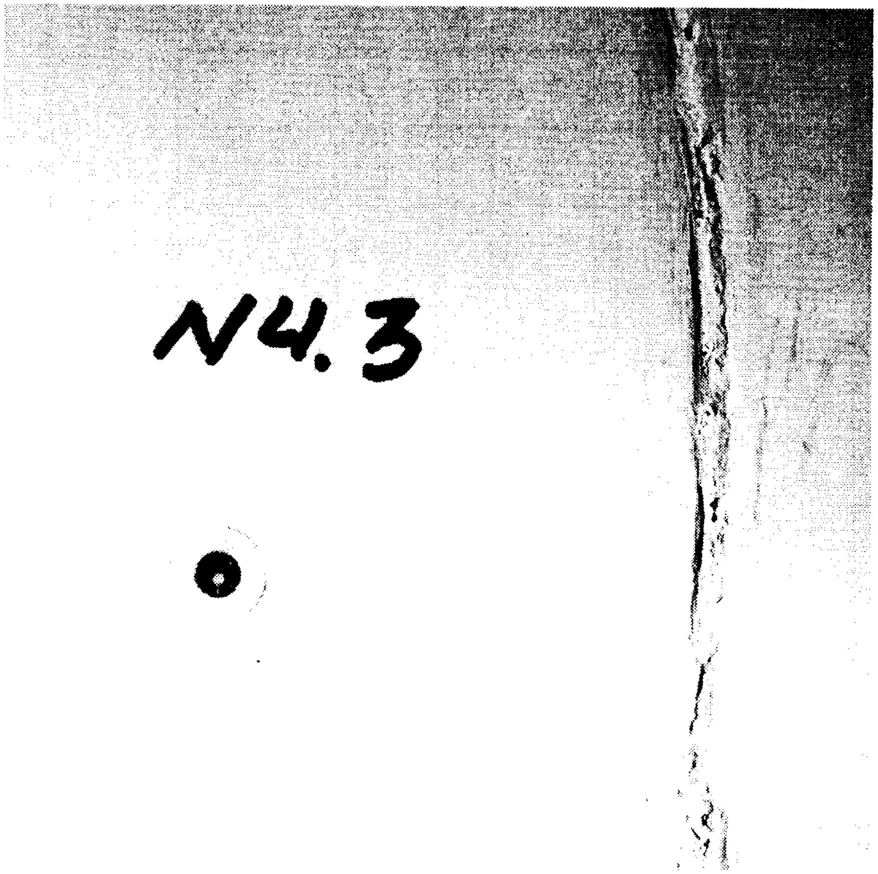


Figure 12: Exterior close-up photograph of Kulite transducer N4.3.

Figure 13: Exterior close-up photograph of Kulite transducer S2.

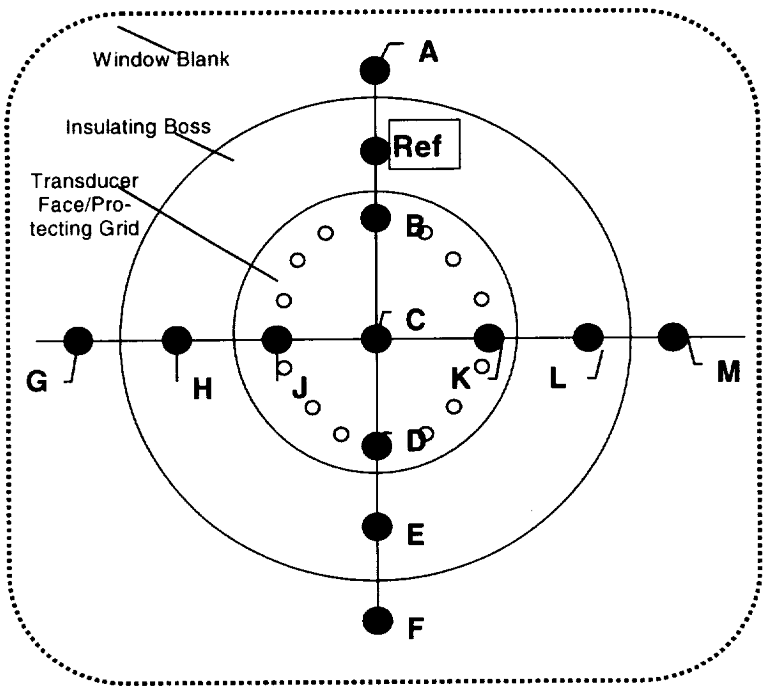


Figure 14: Pattern for Kulite flushness measurements.

Table 4: Map of Kulite transducer flushness.[2]

Id	A	B	C		D	E	F	G	H	J	K	L	M
N1.1	5	4	5	3	19	13	16	7	4	4	4	15	13
N1.2	0	5	10	9	3	-2	6	-8	-4	9	-4	2	23
N1.3	5	-1	7	6	4	8	14	9	6	5	4	-2	-1
N1.4	9	4	20	19	15	1	29	23	5	4	20	6	11
N1.5	12	12	12	10	13	4	14	5	4	1	18	11	15
N2.1	10	14	11	12	9	9	15	18	8	2	23	9	10
N3.1	–	–	–	–	–	–	–	–	–	–	–	–	–
S1	-5	2	22	27	24	-7	-11	-2	7	12	23	-5	-7
N4.1	7	-7	-5	0	-2	-3	-1	12	9	3	9	-28	7
N4.2	9	10	21	21	22	-19	14	14	0	15	13	-9	12
N4.3	10	-3	-3	-3	-1	-2	19	13	-1	1	-2	-6	6
N4.4	2	8	14	14	5	-8	-7	4	-11	7	1	-8	15

[2] Measurements in thousandths of a millimeter. Point C was measured twice to provide an indication of measurement repeatability. Measurements for Kulite N3.1 are not available.

Id	A	B	C		D	E	F	G	H	J	K	L	M
N4.5	4	7	7	9	7	-7	0	16	5	12	2	12	20
N4.6	12	18	16	15	10	-1	9	8	1	11	13	-10	14
N4.7	10	5	12	17	27	13	20	34	18	24	10	2	6
N4.8	7	2	14	16	10	6	10	1	4	0	14	3	13
N4.9	22	8	16	14	13	10	18	38	14	12	11	6	43
S2	16	54	41	39	0	-34	-24	-23	-34	5	20	-20	-13
N5.1	10	10	17	23	25	5	14	18	9	34	2	-7	5
N6.1	13	19	10	16	5	-17	-10	9	-31	17	13	-8	-5
N7.1	17	18	26	23	22	2	10	16	3	18	20	2	9
N7.2	10	14	10	16	3	-4	23	9	-2	-1	23	2	6
N7.3	11	20	21	19	28	2	4	5	-3	35	14	3	24
N7.4	2	2	1	0	3	1	8	4	9	11	0	-4	10
N7.5	13	13	14	16	16	1	14	16	2	11	13	3	16

2.1.2.2 Accelerometers

The choice of acceleration transducer was guided by several requirements: good for high temperatures generated during supersonic flight, very light weight in order to minimize modifying the dynamic behavior of the thin fuselage skin panels, and good frequency response up to 10 kHz. The chosen accelerometer was PCB Piezotronics model M359B15. A specification sheet for this transducer is provided in Figure 48, Appendix B.

Six such accelerometers were installed in the vicinity of window blanks 1, 2, 4, 5, 6, and 7, always just downstream and a little above that window blank. Table 5 shows the approximate accelerometer locations referenced to the closest window blank. Figure 15 shows the locations graphically.

Table 5: Accelerometer locations.

Accelerometer	Closest Window Blank
10.11	1
10.12	2
10.13	5
10.14	6
10.15	7
10.16	4

The accelerometers were mounted by screwing them into mounting bases, which were glued to the inside of the outer fuselage skin.

As a sample, the installation of accelerometer 10.12 next to window blank 2 is described here. This installation was typical of all six accelerometers. Referring to Figure 16 (excerpt from a drawing provided by Tupolev): Window blank 2 replaced the window between frames 38 and 39. Note that Figure 16 shows the port side whereas the window blanks and accelerometers were actually installed on the starboard side. Accelerometer 10.12 was installed just downstream of window blank 2 between frames 39 and 40, and on a panel between stringers 13 and 14, indicated by the symbol ⊗. Figure 17 shows more details of that panel: skin minimum thickness is 1.4 mm (55 mil); frame thickness is 2.5 mm; thickness of stringer 13 is 3 mm, of stringer 14 it is 2 mm. Note that the skin, stringers, and frames are all milled from a solid block of aluminum. Figure 17 also indicates the original accelerometer position (indicated by M359B15) in the center of the panel. Before the first data acquisition flight, the location was changed to a position 3/8 of the panel height from the bottom, and 3/8 of the panel length from the side (indicated by ⊕). This was done in order to capture as many structural modes as possible and still providing adequate signal amplitude.

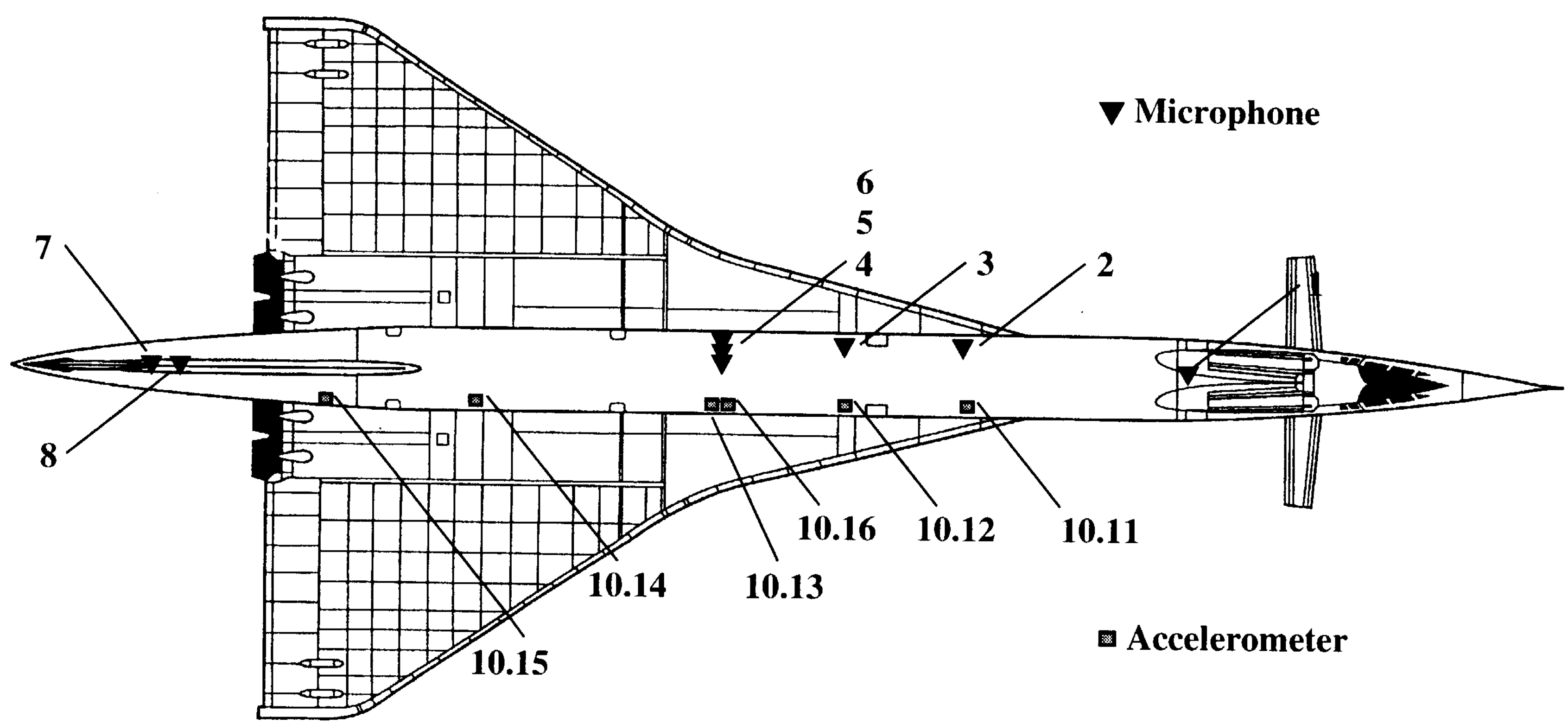


Figure 15: Location and identification of interior microphones and accelerometers.

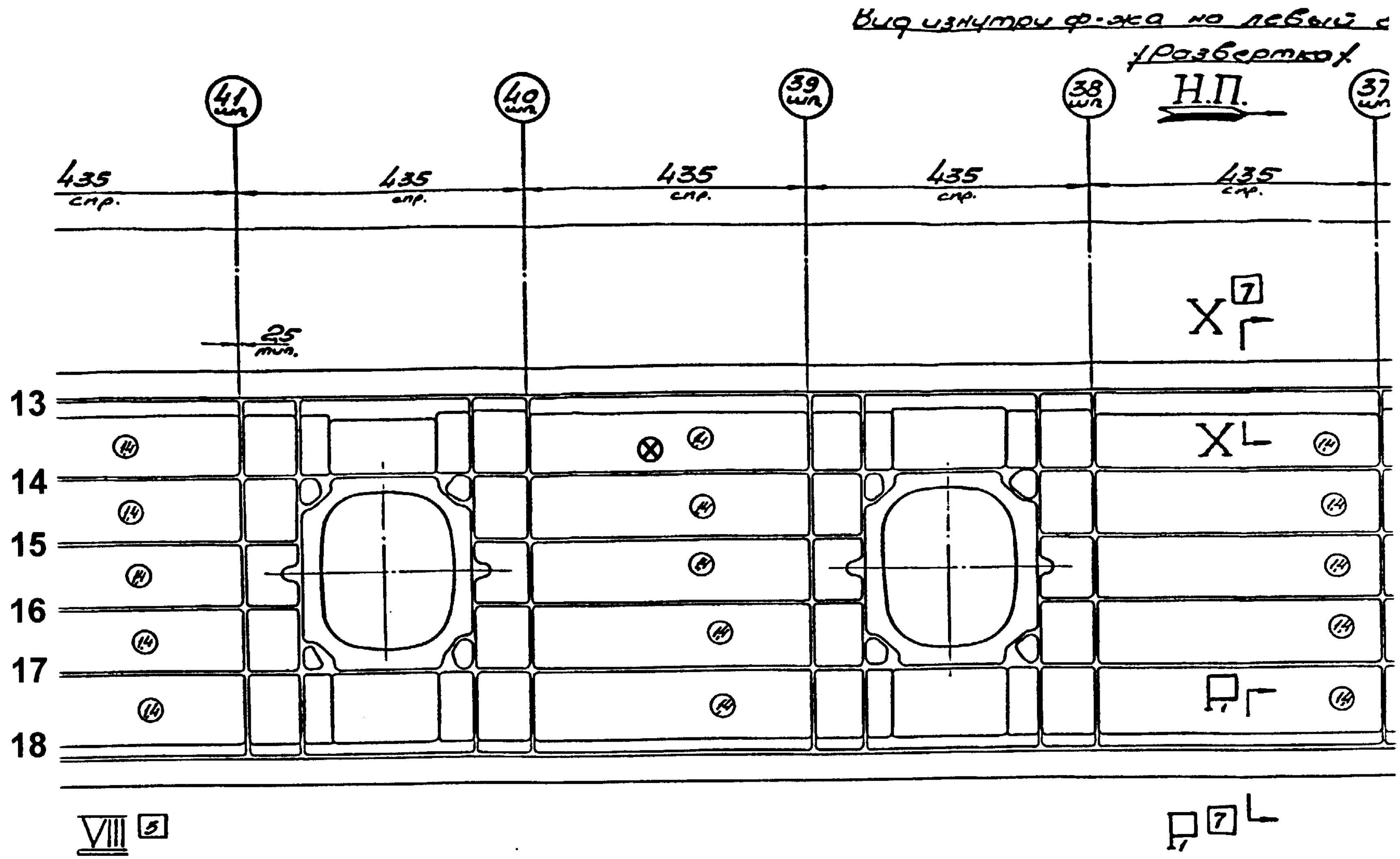


Figure 16: View of accelerometer 10.12 location from inside the fuselage.

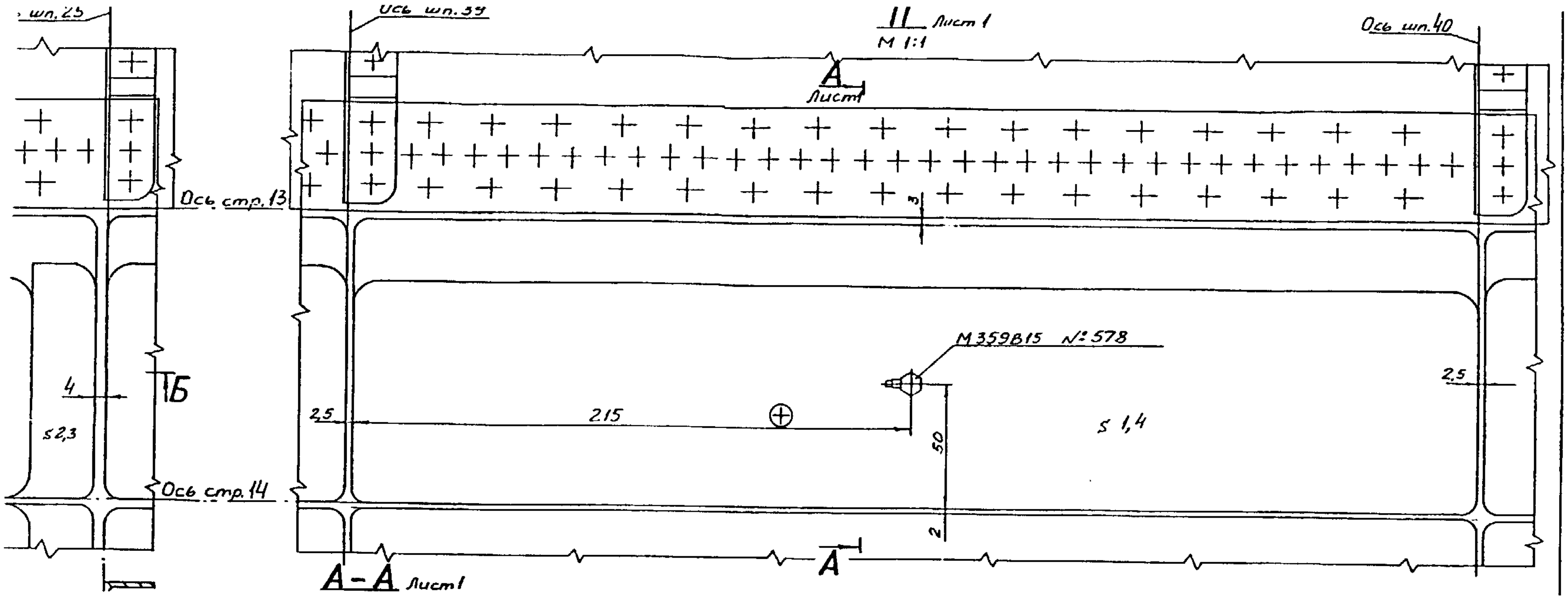


Figure 17: Close-up view of accelerometer 10.12 location from inside the fuselage. Panel is between frames 39 and 40, and stringers 13 and 14.

2.1.2.3 Microphones

Standard Bruel & Kjaer condenser microphones and preamplifiers were used to obtain the cabin noise measurements. One-half inch diameter microphone cartridges (types 4165 and 4166) were chosen because of their high sensitivity (50 mV/Pa) and frequency range (2.6 Hz – 10 kHz). A high sensitivity microphone was required because the B&K 2811 eight channel multiplexer used provides only power, not amplification. Because of the nature of the sound field in the cabin and frequency range of interest, it was felt that the free field (type 4165) and pressure/random (type 4166) microphone cartridges could be used interchangeably. The microphone locations and cartridges used are provided in Table 6 and are shown graphically in Figure 15. A photograph of a typical microphone/preamplifier pair is shown in Figure 18. Also shown in the photograph is an adapter (B&K type JJ 2614) which was used in the laboratory to simulate an input to the system without the use of a microphone cartridge.

Table 6: Microphone locations.[3]

Mic No.	Cartridge Type	Location
1	4165	In the cockpit, clamped to the left pilot seat, close to pilot's right ear
2	4165	On the left side, opposite window blank 1, where aisle seat would be
3	4165	On the left side, opposite window blank 2, where aisle seat would be
4	4165	On the left side, opposite window blank 4, where aisle seat would be
5	4165	On the left side, opposite window blank 4, between aisle and window seat
6	4166	On the left side, opposite window blank 4, where window seat would be
7	4165	In rear instrumentation compartment, approximately left/right centered, down 8 inches from a rail in the ceiling, 51.5 inches from the compartment's rear bulkhead, roughly 2 feet behind the engine nozzle exit plane.
8	4166	In rear instrumentation compartment, approximately left/right centered, down 7.75 inches from a rail in the ceiling, 101.75 inches from the compartment's rear bulkhead, roughly 2 feet in front of the engine nozzle exit plane

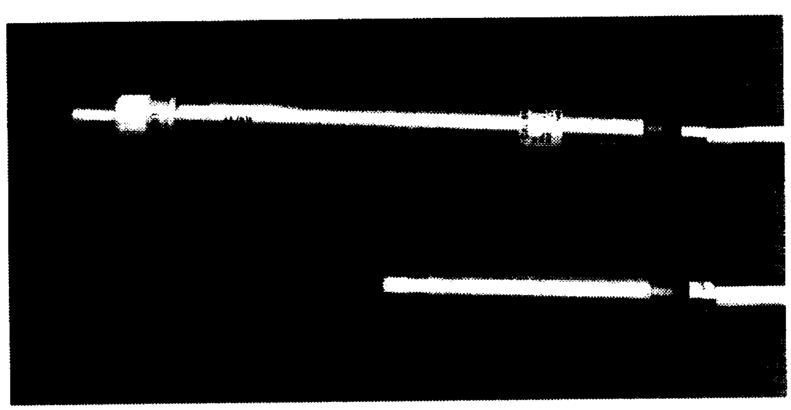


Figure 18: Photograph of Bruel & Kjaer ½-inch microphone and preamplifier.

[3] Microphones 2 through 6 were mounted at a height of where a sitting passenger's head would be.

B&K preamplifier types 2639 or 2645 were used interchangeably. Both have similar response characteristics when used in combination with the type 4165 and 4166 microphone cartridges. The feature of the type 2645 allowing insert-voltage type calibration was not utilized. Ten-meter B&K extension cables (type AO 0028) were used, often in several lengths, to span the distance between the B&K 2811 multiplexer mounted in the instrumentation pallet (see Section 2.1.4) and the microphone location. A plastic insulating tubing, trade name "Tygon," was used to electrically insulate the connections, between lengths of extension cables and preamplifiers, from the aircraft.

The originally planned location for Microphones 7 and 8 was in the rear passenger cabin opposite window blanks 6 and 7. Tupolev had built and installed appropriate supports. However, when U.S. team members first heard the intense noise from engine controls and power conversion equipment in that area it became obvious that no useful measurements could be made in that area since boundary layer noise would be masked or severely contaminated by this equipment noise. The decision was made to relocate these microphones to the rear instrumentation compartment which was separated acoustically from the passenger cabin by a double bulkhead separated by approximately 1-foot. A light-weight door in the forward bulkhead allowed entry into the instrumentation compartment. The installation is shown in Figure 19, where the view is towards the rear with microphone 7 behind microphone 8 (microphone 8 is the one in the foreground).

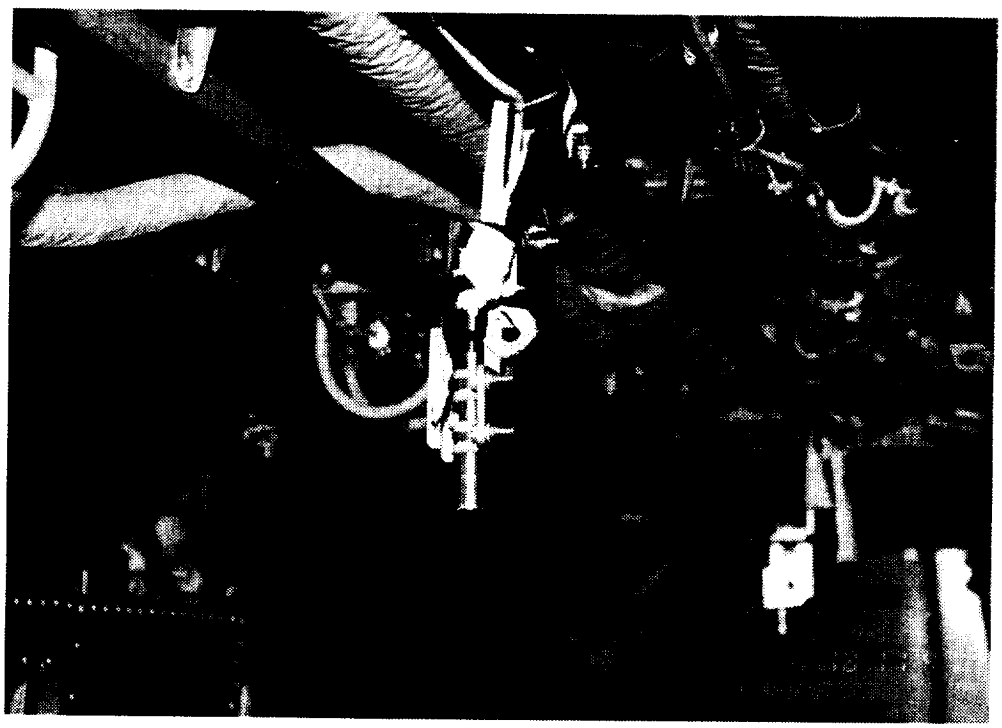


Figure 19: Photograph of microphones 7 and 8 installed in rear instrumentation compartment.

The rear instrumentation compartment has an irregular shape. Approximate dimensions are given in Figure 20. Most of the walls were covered with metal panels perforated with many holes. These panels are held in place with sometimes loosely fitting quick-disconnect devices which allows the panels to rattle. There are no windows. The floor and the rear bulkhead consist of bare metal. The door seemed to be made from fiberglass and was also bare.

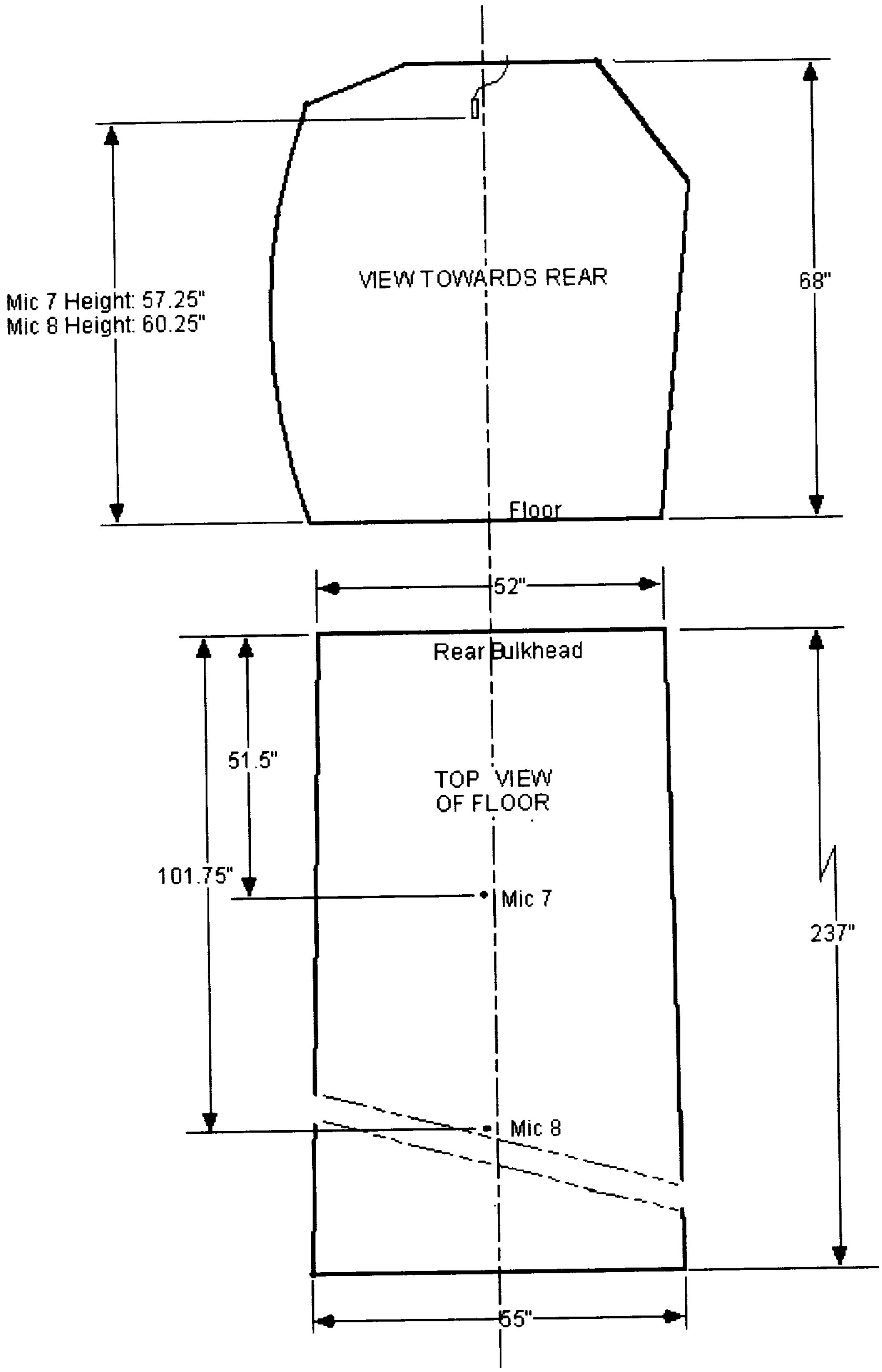


Figure 20: Sketch of rear instrumentation compartment.

2.1.3. Signal Conditioning

2.1.3.1 Kulite Signal Conditioning

Signal conditioning for Kulite pressure transducers was provided by special instrumentation designed and fabricated at NASA LaRC. Three multiple-channel units were built and mounted by Tupolev on the trim panels in the vicinity of the window blanks. An 8-channel unit was mounted near window blank 1 to provide signal conditioning to Kulite transducers N1.1-1.5 and N2.1. Two channels were available for backup purposes. An 18-channel unit was mounted near window blank 4 to provide signal conditioning to Kulite transducers N3.1, S1, N4.1-4.9, S2 and N5.1. Five channels were available to serve as backup. A second 8-channel unit was mounted near window blank 7 to provide signal conditioning to Kulite transducers N6.1 and N7.1-7.5, leaving two channels as backup.

An 8-channel unit is pictured in Figure 21. Power (±15V DC) was supplied from the pallet via the rightmost connector shown in the photo. Amplified signals were returned to the instrumentation pallet via a separate connection (to the left of the power connector) to reduce electrical noise. Four-pin Microtech brand connectors were used to connect the transducers so that they could be easily switched to different signal conditioning channels in the event of a signal conditioning card failure.

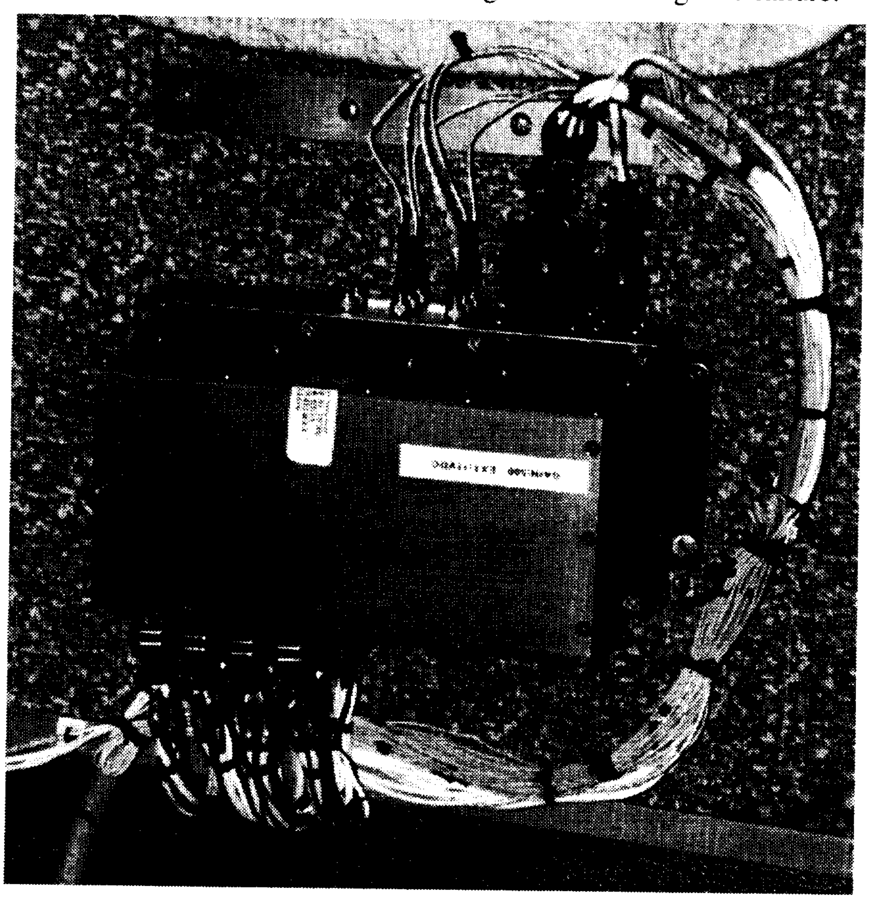


Figure 21: Photograph of an 8-channel Kulite signal conditioning unit.

Internal to each unit were several two-channel signal conditioning cards. Each card was configured to provide an excitation voltage of 11 VDC. Based upon expected levels, a linear gain of 500 was programmed into the two-stage amplifier in order to make the most out of the dynamic range of the Metrum recorder (see Section 2.1.4.1.1). The first stage is capacitively coupled to the second stage to block the DC component of the input, i.e. the second stage only amplifies the AC signal. The second stage passes frequencies from 1 Hz to 50 kHz. Because the maximum output voltage from the first stage is 20 volts pk-pk, special precautions were taken not to over-range this stage with the amplified DC signal. The DC component could be significant since the Kulite pressure transducers operated in a differential mode. Hence, the difference in pressure across the fuselage wall formed a sizeable DC component at altitude. A first stage gain of 100 and second stage gain of 5 was chosen to make up the total gain of 500.

2.1.3.2 Accelerometer Signal Conditioning

Accelerometer signal conditioning was provided by Endevco amplifiers model 2685M10B. These units were selected because they were small and rugged making them suitable for the application. The amplifiers were mounted by Tupolev on the trim panels in the vicinity of the accelerometers.

A typical unit is pictured in Figure 22. Power (28V DC) was supplied from the pallet via the large Viking brand connector, which also returned the amplified signals back to the pallet. A 2-pole Butterworth low-pass filter was set at 20 kHz. Based on expected vibration levels, each amplifier was set to a linear gain of 10 by Wyle Laboratories in Hampton, Virginia. The precise gain is indicated in the calibration files, see Section 5.4.

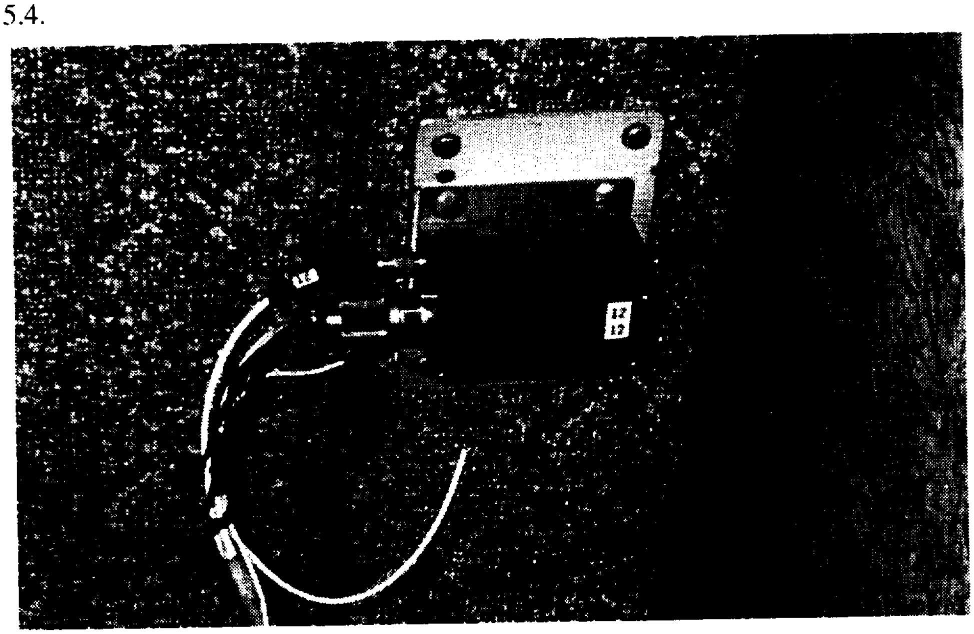


Figure 22: Photograph of the amplifier for accelerometer 10.12.

2.1.3.3 Microphone Signal Conditioning

Power for microphone preamplifiers and polarization voltage for the condenser microphones was provided by an eight-channel Bruel & Kjaer type 2811 multiplexer. The multiplexer and a spare unit were mounted in the instrumentation pallet (see Figure 23; see also Section 2.1.4). The scanning function of the multiplexer was not utilized, i.e. all eight microphone outputs were available simultaneously. A 200V polarization voltage was provided to each microphone. Because the multiplexer did not provide any amplification of its own, high sensitivity microphone cartridges were used (see Section 2.1.2.3).

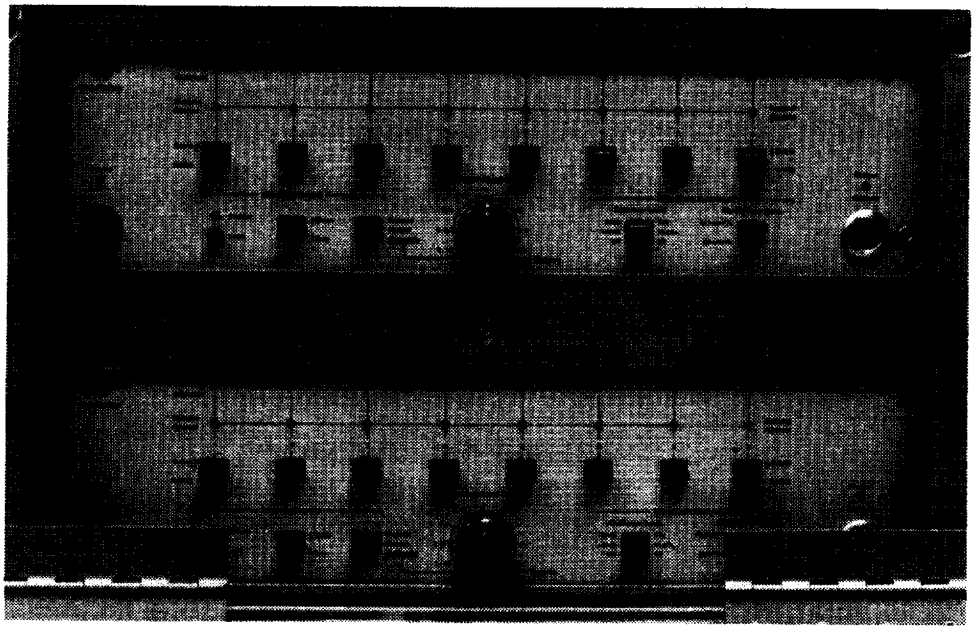


Figure 23: Photograph of 8-channel microphone multiplexers in instrumentation pallet.

2.1.4. Instrumentation Pallet

The instrumentation pallet was designed and fabricated from the ground up based on the particular requirements of the experiment, i.e. the pallet was not something that was available from another flight test experiment. In this section, the functional design, electronic and mechanical design and fabrication, transportation and storage, and instrumentation changes made during the flight test program will be discussed.

2.1.4.1 Functional Design

Prior to the detailed mechanical and electrical design, a functional design was developed which specified recording, channel switching, anti-aliasing filter and signal monitoring requirements.

2.1.4.1.1. Recording Requirements

A high channel count recorder with a high aggregate sampling rate was required to capture signals up to the desired 11.2 kHz. This frequency corresponds to the upper frequency of the third-octave band with center frequency of 10 kHz. The recorder selected for the application was a Metrum RSR 512 digital tape recorder. A photograph of the Metrum RSR 512 recorder in the instrumentation pallet is shown in the upper left corner of Figure 24. Its features include up to 32 analog input channels, 12-bit quantization (70 dB dynamic range), aggregate sampling rate of up to 1280k samples/second, selectable input voltage ranges of ±0.1V to ±10V peak in 1-2-5 steps, auto-range capability and an optional high speed digital output (HSDO) port for digital transfer of data to a separate computer. The specific unit used on the aircraft had 32 analog input channels. A second unit having the HSDO option, but not installed on the aircraft served as backup and was used for post-flight data analysis (see Section 5.1).

The sampling rate used for all transducers was 40 kHz (10 kHz bandwidth times a sampling density of 4 samples/cycle). This sampling rate produced a Nyquist frequency of 20 kHz, the closest available above the 11.2 kHz desired. The sampling rate for the IRIG-B time code and voice annotation channels was 20 kHz (5 kHz bandwidth times a sampling density of 4 samples/cycle). For acquisition of reverberation time data, the sampling rate was increased to 160 kHz (40 kHz bandwidth times a sampling density of 4 samples/cycle) to better capture the transient waveform.

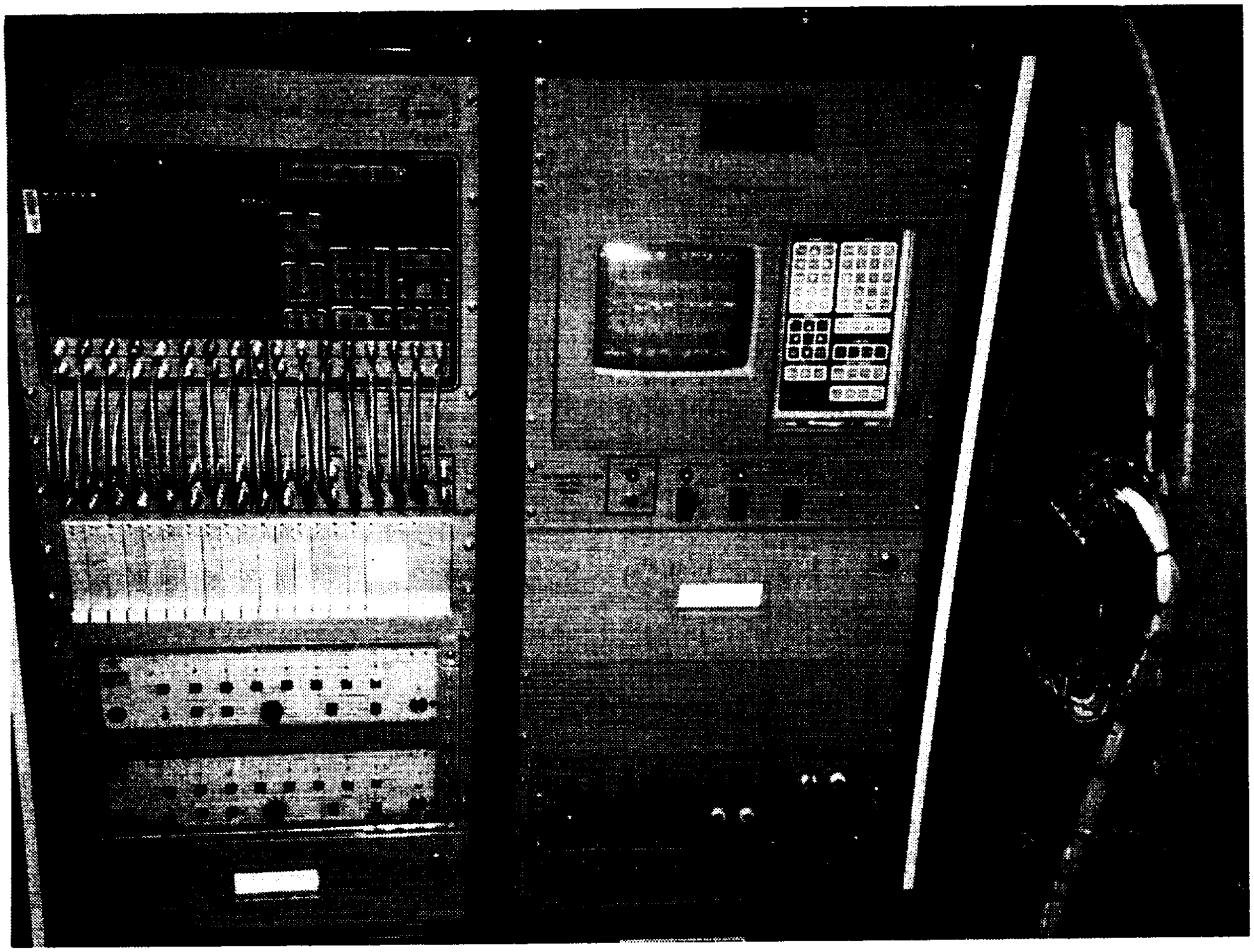


Figure 24: Photograph of instrumentation pallet installed in TU-144LL passenger cabin.

The dynamic range of recording was maximized through a somewhat elaborate procedure of auto-ranging all inputs with the exception of voice annotation and IRIG-B time code. Prior to each acquisition, the *brief* auto-range mode was enabled. In the *brief* mode, the peak voltage on each channel is initially set to the 0.1V (most sensitive) value. By starting each channel at its most sensitive value, a low sensitivity from a previous test condition would not persist and penalize the dynamic range. During the course of the *brief* mode, an over-ranging channel would have its peak voltage increased by the auto-range logic until the channel no longer over-ranged or until the least sensitive 10V value had been reached. In the *brief* mode, the entire auto-range process usually took about a second. Because the signals could be non-stationary, a longer period over which the process was performed was thought to be desirable. Therefore, following the *brief* mode auto-range, a *continuous* mode auto-range was enabled. In the *continuous* mode, each channel was set so that its peak voltage could be increased (but not decreased) if positive or negative peaks of the input signal exceeded a threshold value. By not allowing the peak voltage to decrease, the condition of it being reduced due to a low level signal at the end of the auto-range cycle was avoided. In other words, during the *continuous* mode, the peak voltage could only be further increased from level set during the *brief* mode. The *continuous* mode was enabled for a user selectable period typically on the order of ten seconds. All auto-ranging functions were completed prior to the acquisition to avoid the possibility of changing gains during the acquisition cycle. While the Metrum recorder is capable of this, the added complication in terms of data reduction was thought to outweigh any added benefit. The details of the auto-range process are included in the flight operational procedures in Appendix F. Note that for take-off conditions, the auto-range process was not invoked and the gains were set manually prior to flight based on expected levels. As such, it took several attempts to capture the take-off condition properly.

2.1.4.1.2. Channel Switching Requirements

The total channel count was 41. It consisted of 25 Kulite fluctuating pressure transducers, 6 accelerometers, 8 microphones, IRIG-B time code, and a voice channel for the operator to annotate the data records with any anomalies or other significant occurrences. The IRIG-B time code was used to synchronize the experiment 2.1 data with the Damien PCM system used to record other flight data [1]. Because a 32-channel Metrum recorder was selected, some channels had to be switched in one of two banks (A and B). The channels were grouped together according to Table 7. This configuration was chosen for two reasons. The "Bank A" lineup was selected so that all of the Kulite pressure transducers could be acquired simultaneously. The "Bank B" lineup was selected so that at least the Kulite transducers in the middle of the window blanks would be recorded when the microphones were switched in. Selection of "Bank A" or "Bank B" was performed using a toggle switch mounted on the front panel of the right-hand rack (see Figure 25). A 12-channel switching unit, designed and fabricated at NASA LaRC, was used to simultaneously switch the nine channels associated with each bank. A change was made to the channel lineup following flight 9 after it was determined that the voice annotation was not adding value (see Section 2.1.4.6). The change allowed accelerometer 10.11 to be recorded with the other accelerometers, and Kulite N4.9 to be recorded with the other Kulite transducers in window blank 4, on either bank A or bank B.

Table 7: Channel table.[4]

	Configuration for engine runup and flight 9		Configuration for flights 10, 11, 15, 16, 17 and reverberation time	
	Transducer		Transducer	
Channel	Bank A	Bank B	Bank A	Bank B
1	Kulite N1.1	Kulite N1.1	Kulite N1.1	Kulite N1.1
2	Kulite N2.1	Kulite N2.1	Kulite N2.1	Kulite N2.1
3	Kulite N3.1	Kulite N3.1	Kulite N3.1	Kulite N3.1
4	Kulite S1	Kulite S1	Kulite S1	Kulite S1
5	Kulite N4.1	Kulite N4.1	Kulite N4.1	Kulite N4.1
6	Kulite N4.2	Kulite N4.2	Kulite N4.2	Kulite N4.2
7	Kulite N4.3	Kulite N4.3	Kulite N4.3	Kulite N4.3
8	Kulite N4.4	Kulite N4.4	Kulite N4.4	Kulite N4.4
9	Kulite N4.5	Kulite N4.5	Kulite N4.5	Kulite N4.5
10	Kulite N4.6	Kulite N4.6	Kulite N4.6	Kulite N4.6
11	Kulite N4.7	Kulite N4.7	Kulite N4.7	Kulite N4.7

[4] Shaded blocks are switched.

	Configuration for engine runup and flight 9		Configuration for flights 10, 11, 15, 16, 17 and reverberation time	
	Transducer		Transducer	
Channel	Bank A	Bank B	Bank A	Bank B
12	Kulite N4.8	Kulite N4.8	Kulite N4.8	Kulite N4.8
13	Kulite S2	Kulite S2	Kulite S2	Kulite S2
14	Kulite N5.1	Kulite N5.1	Kulite N5.1	Kulite N5.1
15	Kulite N6.1	Kulite N6.1	Kulite N6.1	Kulite N6.1
16	Kulite N7.1	Kulite N7.1	Kulite N7.1	Kulite N7.1
17	Accel 10.12	Accel 10.12	Accel 10.12	Accel 10.12
18	Accel 10.13	Accel 10.13	Accel 10.13	Accel 10.13
19	Accel 10.14	Accel 10.14	Accel 10.14	Accel 10.14
20	Accel 10.15	Accel 10.15	Accel 10.15	Accel 10.15
21	Accel 10.16	Accel 10.16	Accel 10.16	Accel 10.16
22	Kulite N1.2	Accel 10.11	Kulite N1.2	Kulite N4.9
23	Kulite N1.3	Mic 1	Kulite N1.3	Mic 1
24	Kulite N1.4	Mic 2	Kulite N1.4	Mic 2
25	Kulite N1.5	Mic 3	Kulite N1.5	Mic 3
26	Kulite N4.9	Mic 4	Kulite N4.9	Mic 4
27	Kulite N7.2	Mic 5	Kulite N7.2	Mic 5
28	Kulite N7.3	Mic 6	Kulite N7.3	Mic 6
29	Kulite N7.4	Mic 7	Kulite N7.4	Mic 7
30	Kulite N7.5	Mic 8	Kulite N7.5	Mic 8
31	IRIG-B	IRIG-B	IRIG-B	IRIG-B
32	Voice	Voice	Accel 10.11	Accel 10.11

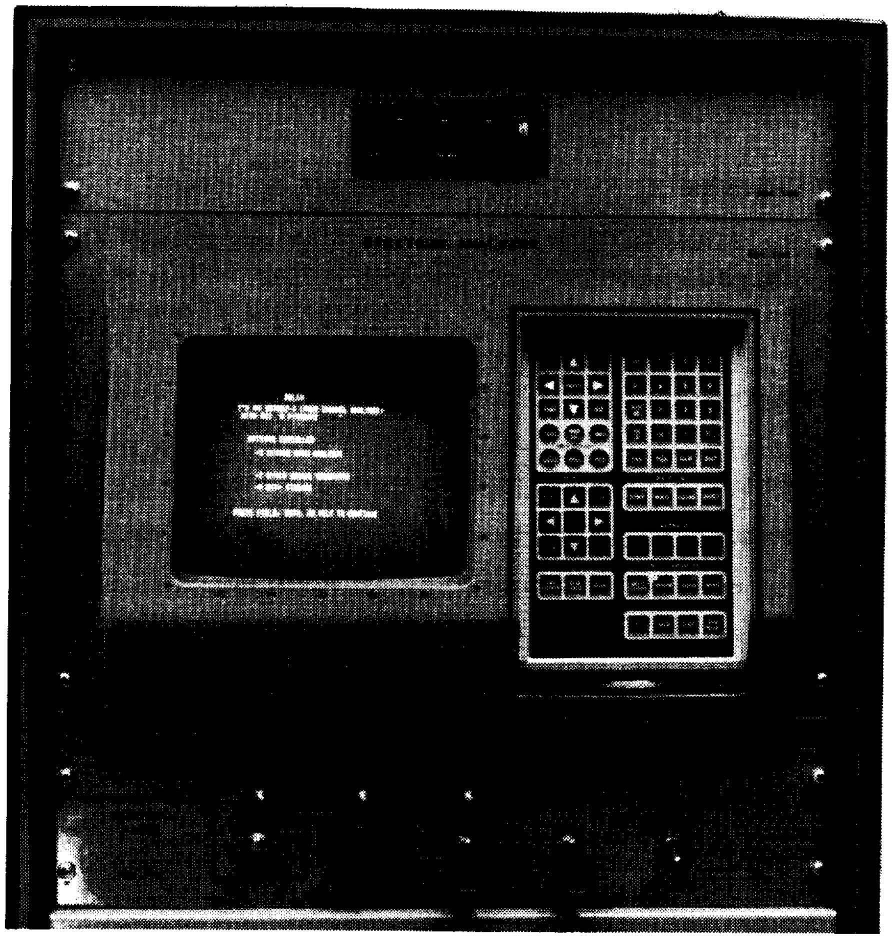


Figure 25: Close-up view of inst. control panel, spectrum analyzer and time code display.

2.1.4.1.3. Filter Requirements

Because the tape recorder used did not have internal anti-aliasing filters, this function was performed using a filter external to the recorder. A Frequency Devices, Inc. 5016 mainframe with plug-in filter cards (model D68L8E-11.2Khz) was selected. Each filter card had four 8-pole, 6-zero elliptic low-pass filters with a –3 dB fixed corner frequency of 11.2 kHz. The corner frequency is clearly seen in the sample data plots of Section 5.2.

2.1.4.1.4. Signal Monitoring

It was important to have a signal monitoring capability on board the aircraft. This was accomplished using a Spectral Dynamics, Inc. SD-380 spectrum analyzer, shown in Figure 25. Two monitor output channels from the Metrum recorder were patched to the SD-380 allowing any of the 41 signals available to the Metrum to be monitored. The original intent of having the unit on board was for the U.S. team to operate it on the ground for diagnostic purposes and for the Tupolev operator to use it in flight to monitor signal quality. Because of the complexity of operation, the latter function was not performed. This was not to the detriment of flight data quality however, as signal input ranges were still monitored on the Metrum bar graph display in order to minimize or eliminate input over-ranges. The SD-380 was particularly useful in verifying the capture of transient reverberation time data (see Section 3.3.2).

2.1.4.2 Electronic Design and Fabrication

The electronic design of the instrumentation pallet was performed by the Flight Instrumentation Branch (FIB) at NASA LaRC.

2.1.4.2.1. Power Utilization

The instrumentation pallet utilized two sources of power on the aircraft; 27 VDC and 115V/400 Hz AC. A wiring schematic for the power control system is provided in Figure 49 (Appendix C), and for the power distribution system in Figure 50, Appendix C. A photograph of the power control panel is shown in Figure 25.

The characteristics of the power control and distribution system are:

- Easily identifiable switch labeled "Master Power On/Off" was provided to allow Tupolev instrumentation operator to shut down all provided instrumentation
- All wire and current loads were protected by flight approved MIL-SPEC circuit breakers.
- Current ratings of wire were determined per NASA LaRC flight specifications (MIL-SPEC 5088L)
- All power supplies have independent short circuit protection
- An electrical load test was performed on the complete system prior to shipment
- Tupolev was responsible for providing 20A of 27 VDC and 20A of 115V/400 Hz AC.

A change to the design was made in the field after finding that Tupolev had utilized an old specification of #12 AWG wire for the 27 VDC power supply line instead of #8 AWG wire. A 25A breaker was substituted for the 20A breaker alleviating the need to re-run the supply line. The change worked without incident.

2.1.4.2.2. Electronic Fabrication

Electronic fabrication was performed according to the following specifications:

- NASA in-house subsystems and wiring were built to NASA handbook 5300.4 standards
- All commercial equipment was disassembled, inspected, and modified as necessary to meet flight requirements (flight hardening)
- All equipment and wiring underwent inspection and review by the NASA LaRC Aircraft Quality Assurance Office during design and fabrication. The Quality Assurance Office performed a final inspection of all equipment and wiring before shipment to Tupolev.

All electrical drawings were reviewed and approved (signed off) by an engineer or senior technician knowledgeable of the technical discipline covered in the drawing. All drawings have an issued date.

2.1.4.2.3. Environmental Testing

Environmental testing was performed on all equipment in certify the operating and non-operating range of the equipment. The requirements were:

- Static Loads: Mechanical design requirements of 1.5g sideward force and 9.0g forward force as specified in FAR 25 (also CAR 4d).
- Vibration: The Tu-144 vibration levels within the passenger cabin were unknown, but expected to be a very low level.

- Temperature: Operating temperature range of +41 to +104 °F, non-operating (storage) temperature range of –31 to +122 °F. Note that information provided by Tupolev indicated maximum cabin temperature condition during takeoff of 86 °F.
- Pressure: Operating pressure range of sea level to 2.4 km altitude (approximately 11 PSIA), non-operating pressure range of 2.4 km altitude to 18.29 km altitude. Tupolev was instructed that the NASA LaRC equipment should be turned off if the aircraft experienced decompression above 2.4 km altitude.

Because NASA LaRC provided instrumentation were previously vibration qualified for use on other transport aircraft such as the B-737, MD-11, B-757, and B-767, no additional vibration or shock tests were conducted.

Operational tests were performed on equipment not previously qualified. Subsystem equipment was individually subjected to a combined temperature/altitude test over the operational temperature range.

Non-operational tests for temperature were conducted by subjecting individual subsystems to –31 °F for 12 hours and +122 °F for 4 hours. Non-operational tests for altitude were conducted by subjecting subsystems to 18.29 km altitude for 30 minutes with a gradual decrease to sea level within 30 minutes.

Results of the operational and non-operational temperature and pressure qualification tests are indicated in Table 8. The B&K multiplexer and Metrum recorder established the minimum and maximum operating temperatures.

Table 8: Environmental testing matrix.[5]

	Non-Operating Condition			Operating Condition		
	Temp (°F)		Altitude (km)	Temp (°F)		Altitude (km)
Instrument	-31	+ 122	18.29	+41	+104	2.4
B&K 2811 Multiplexer	✓	✓	✓	✓	✓	✓
B&K 2639 Preamplifier	✓	✓	✓	✓	✓	✓
SD-380 Spectrum Analyzer	✓	✓	✓	✓	✓	✓
Frequency Devices Filter	✓	✓	✓	✓	✓	✓
Metrum RSR-512 Recorder	✓	✓	✓	✓	✓	✓
NASA Kulite Amplifiers	✓	✓	✓	✓	✓	✓
NASA Data Multiplexer	✓	✓	✓	✓	✓	✓
Kulite Pressure Transducers	✓	✓	✓	✓	✓	✓
PCB Accelerometers	✓	✓	✓	✓	✓	✓
Endevco Accelerometer Amplifier	✓	✓	✓	✓	✓	✓
Marathon DC/AC Power Supply	✓	✓	✓	✓	✓	✓
Time Code Reader	✓	✓	✓	✓	✓	✓

[5] Shaded entries indicate qualification test performed to required minimums. Otherwise, equipment was previously qualified.

	Non-Operating Condition			Operating Condition		
	Temp (°F)		Altitude (km)	Temp (°F)		Altitude (km)
Instrument	-31	+ 122	18.29	+41	+104	2.4
Abbott Power Supplies	✓	✓	✓	✓	✓	✓

2.1.4.3 Mechanical Design and Fabrication

The mechanical design of the instrumentation pallet was performed by the Engineering Design Branch (EDB) at NASA LaRC.

2.1.4.3.1. Mechanical Design

The pallet was designed for side loads of 1.5g, upward loads of 3.0g, forward loads of 9.0g and downward loads of 6.0g. Special attention was paid to high stress areas including welds in the corners of the pallet structural members, and seat rails and attachment fittings. A pallet design was adopted based on ones previously used for other transport aircraft applications. The design incorporated the following attributes:

- Two Emcor II racks were joined (side-by-side) to form the pallet which housed all instrumentation except for the remote signal conditioning units and transducers. The pallet was flight hardened according to NASA LaRC engineering requirements.
- Standard aircraft structural fasteners were used to install all instrumentation. Any exceptions were individually approved by the NASA LaRC Aircraft Quality Assurance Office.
- Actual instrumentation weights and heights were used to compute margins of safety for loads certification.
- The pallet was completely enclosed except for cooling air inlets located at the bottom of each rack and fans at the top of each rack. Air inputs and outlets were covered by a wire mesh.

Tupolev was responsible for mating the tie down fittings to the pallet base and to the Tu-144 seat rails during installation.

2.1.4.3.2. Mechanical Fabrication

Fabrication of the pallet was performed at NASA LaRC according to the following:

- Mounting and installation of all instrumentation underwent inspection and review by the NASA LaRC Quality Assurance Office and the EDB during fabrication.
- NASA LaRC furnished instrumentation was inspected according to LaRC aircraft quality assurance guidelines normally used for transport aircraft, such as the B-737.
- The instrumentation pallet was delivered with quality assurance documentation.

A photograph of the instrumentation pallet is shown in Figure 24. The approximate total pallet weight was 744 lb. and center of gravity location was 21-in. above the floor. This resulted in pallet loads well below those of typical B-737 pallets employed at NASA LaRC.

2.1.4.4 Design Reviews

Design and fabrication of the instrumentation pallet was performed in accordance with the NASA LaRC handbook (LHB 7910.1, September 1997) entitled, "Flight Research Program Management." A Combined Mechanical/Electronic Design Review was held at NASA LaRC on 30 August 1995. No action items were raised as a result of this review and the project was cleared to proceed as planned.

The instrumentation plan was presented by the U.S. team experiment coordinators to V. Sablev of Tupolev at the NASA DFRC in February 1995. The functional instrumentation system was then reviewed and demonstrated for Messrs. Sablev and Andrianov at the NASA LaRC in November 1995.

2.1.4.5 Transportation and Storage

Detailed flight test procedures were developed for Tupolev operators and reverberation time procedures for U.S. team operators (see Section 3) following completion of the instrumentation fabrication. In March 1996, the instrumentation system was shipped to Russia by Boeing directly from the NASA LaRC. The equipment arrived in Russia in June 1996 and was stored there until its installation in July 1997.

2.1.4.6 Instrumentation Changes

The following changes were made to the instrumentation during the course of the program:

- It was found after flight 9 that the voice annotation channel was not being utilized. To exploit the full capacity of the recorder, it was decided to move accelerometer 10.11 from channel 22B to channel 32 and to duplicate Kulite N4.9 so that it would appear on both 26A and 22B. In this manner, all transducers in window blank 4 and all accelerometers were recorded in both switch positions. The change was implemented on 14 October 1997.
- Following flight 10, moisture penetrated Kulite N3.1 and froze, causing it to fail. It was replaced on 10 November 1997 with a spare transducer. In addition, Kulite N4.3 was relocated to a spare signal conditioning channel because of intermittent anomalous behavior.

2.2. Installation and Checkout

Mechanical installation of the instrumentation pallet and remote signal conditioning equipment was performed jointly by Tupolev and the U.S. team during the period 28 July 1997 – 08 August 1997.

During the period 10 – 12 September 1997 a complete checkout of the instrumentation was performed on the aircraft. Checks of the power to the instrumentation pallet and power distribution internal to the pallet were performed, followed by functional checks of the equipment within the pallet. Single frequency and broadband signals were injected into the back of the pallet and read through the system in order establish all internal signal cables were properly functioning. Power to the Kulite and accelerometer remote signal conditioning units was checked out.

In order to check out the Kulite signal conditioning units, a single spare Kulite was connected into each Kulite signal conditioning channel (one at a time) and the microphone calibrator (see Section 2.3.2) was used as an excitation source. All Kulite transducers were hooked up to their respective signal conditioning units and measurements were made to determine the background noise level and any DC offset.

Accelerometer signal conditioning units were checked out by connecting a single spare accelerometer into each accelerometer signal conditioning unit (one at a time) and a 1-g shaker was used as an excitation source. All accelerometers were hooked up to their respective signal conditioning units. Background noise measurements on the accelerometer amplifiers were made and Tupolev was tasked with hooking up a grounding wire in a manner which provided a quick recovery from RF interference.

The microphone system was checked out by connecting a single microphone and preamplifier into each of the eight interior microphone channels and using the microphone calibrator as an excitation source. The 400 Hz electrical noise was found to be about 35 dB below the 94 dB calibrator signal.

2.3. Transducer Calibrations

2.3.1. Accelerometer Calibrations

Because it was not possible to perform an in-situ calibration of the accelerometers, the factory calibrations were utilized. All calibration files, see Section 5.4, therefore indicate the same accelerometer calibrations for all flight and ground tests.

2.3.2. Microphone Calibrations

Microphone calibrations were performed on the aircraft on the day of the particular experiment. Only pre-test calibrations were performed for the ground engine runup and reverberation experiments. At the recommendation of Eduard Andrianov, both pre- and post-test calibrations were performed for the flight tests. The reason for doing this was because the change in cabin pressure was previously found to change the microphone calibration. In general, a very slight decrease in the sensitivity between the pre- and post-test calibration was observed. The calibrations were found to be very consistent over the course of all experiments on the Tu-144LL.

The calibrations were performed using a GenRad 1986 Omnical Sound Level Calibrator at 114 dB and 1 kHz. Microphones were allowed to warm-up for two hours prior to the pre-test calibration. This requirement was sometimes difficult to meet during the day of flight as Tupolev personnel were eager to complete this work in preparation for the flight. There does not appear to have been any negative result of this.

2.3.3. Kulite Calibrations

The calibrations were performed using a Boeing-built device capable of generating calibrated 124 and 150 dB sources at 250 Hz, and a broadband noise. The device had an internal microphone whose output was available via a BNC connector. The output from the internal microphone served as a check of the calibrated levels and also as a reference for the phase calibration data. The microphone signal was fed to the instrumentation pallet using a single cable which was made long enough to reach from the furthest window blank (no. 1) to the instrumentation pallet. A single cable was used to avoid any phase change from being introduced between window blanks located at different positions from the instrumentation pallet. After installation of the transducers, it was found to be difficult to ensure proper alignment of the calibrator with the Kulite transducer. A simple, but effective, alignment rig was fabricated at NASA LaRC prior to the first test to assist in this endeavor.

The process of performing Kulite calibrations was a somewhat difficult one because of the locations of the transducers on the outside of the aircraft. This required a long cable to get the reference signal back to the Metrum recorder and the use of walkie-talkies to communicate between personnel inside and outside the aircraft. The location of the aircraft at Zhukovsky made the process even more difficult because the open hangar in which it was parked acted like a wind tunnel. As the weather became cold, this presented a real obstacle. Because of these factors, Kulite calibrations were performed on a limited number of occasions, and not for every flight as was the case with the microphone calibrations.

Kulite magnitude calibrations were performed using the 150 dB level to obtain the greatest signal to noise ratio. Only a few of the initial calibrations were performed using the 124 dB level. The calibrations and their use are provided in Table 9. The calibration data is provided in the calibration data files, see Section 5.4.

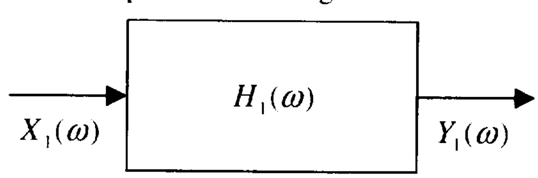
Table 9: Kulite magnitude calibration look-up table.[6]

Calibration Date	Kulite Transducers Calibrated	Level (dB)	Use
16 Sep 97	N1.1-1.5, N2.1	150	Ground, Flight 9
16 Sep 97	N5.1, N6.1	124	Ground
23 Sep 97	N3.1, S1, N4.1-4.9, S2, N7.1-7.5	150	Ground, Flight 9
02 Oct 97	N5.1, N6.1	150	Flight 9
20 Oct 97	N3.1, S1, N4.1-4.9A/B, S2, N5.1, N6.1, N7.1-7.5	150	Flight 10
21 Oct 97	N1.1-1.5, N2.1	150	Flight 10
03 Nov 97	All except N3.1 and N4.3	150	Flights 11, 15, 16, 17, Reverb
10 Nov 97	N3.1, N4.3	150	Flights 11, 15, 16, 17, Reverb

Kulite magnitude calibrations in the Tu-144LL were very consistent and close to calibrations performed in the laboratory. Therefore, while it would have been desirable to obtain additional calibrations between flights 11 and 17, it does not appear to have been absolutely essential.

Kulite phase calibrations were performed using a broadband noise source. The objective of these calibrations was to determine the phase difference between transducers so that a correction could be applied, if necessary, for subsequent boundary layer cross spectral density calculations.

The data for the phase calibrations was reduced but not processed to obtain the phase corrections. A process for performing phase calibrations utilizing the data acquired is outlined here. For each Kulite transducer, the reference microphone and Kulite signals were recorded. Assuming a linear system, the transfer function relationship for Kulite 1 is given as:



$$X_1(\omega) = \frac{Y_1(\omega)}{H_1(\omega)}$$

where $X_1(\omega)$ is the Fourier transform of input source, $x_1(t)$, as measured by the reference microphone, $Y_1(\omega)$ is the Fourier transform of Kulite 1 signal, and $H_1(\omega)$ is the transfer function between the output of Kulite 1 and the input source. A similar relationship exists for the nth Kulite. Assuming the noise source doesn't change, i.e. $X_1(\omega) = X_n(\omega)$, the transfer function between Kulite transducers (and hence the phase) may be obtained from the expression

$$\frac{Y_1(\omega)}{Y_n(\omega)} = \frac{H_1(\omega)}{H_n(\omega)} = H_{1n}(\omega)$$

[6] Kulite N4.9 patched to Metrum channel 26 on bank A and channel 22 on bank B on 14 Nov 97. The A/B designation indicates calibration performed on both bank A and bank B.

In this manner, adjustments to the phase between transducers may be made on a frequency-by-frequency basis.

A list of the phase calibrations performed is provided in Table 10. Data from the Kulite phase calibrations in the form of time histories is not included in the CD-R set described in Section 5.3.

Table 10: Kulite phase calibration information.

Calibration Date	Kulite Transducers Calibrated
15 Sep 97	N3.1, S1, N4.1, N4.2, N4.4, S2, N7.1-7.5
16 Sep 97	N1.1-1.5, N2.1, N4.3, N4.5-4.9, N5.1, N6.1
23 Sep 97	N3.1, N4.8, S2, N7.1, N7.2, N7.5
02 Oct 97	N4.3, N5.1, N6.1, N7.2, N7.5
21 Oct 97	N4.9A/B
10 Nov 97	N3.1, N4.3

3. Procedures

3.1. *Flight Tests*

Because the TU-144LL was an experimental aircraft, only the essential crew was allowed on board during flight operations. The on-board equipment provided by the U.S. team needed to be operated by Russian personnel not familiar with acoustic instruments. Detailed step-by-step instructions were developed by the U.S. team in English and translated into Russian by personnel at IBP Aircraft. In order to ensure the translation's correctness critical parts of the Russian instructions were translated back into English without reference to the English original. In this way, several problems were found and eliminated. The final procedure document appears in Appendix F.

Two members of the TU-144LL flight crew (Tupolev personnel) were given in-depth training, theoretical as well as hands-on using the on-ground Metrum recorder, as well as on-board using the instrumentation rack, concentrating on acquiring data in flight. Several Tupolev engineers were given training concentrating on pre-flight and post-flight calibration and data preservation procedures. For flights 9, 10, and 11, pre- and post-flight activities were carried out by the U.S. team members with assistance from Tupolev personnel. For flights 15, 16, and 17, these were carried out solely by Tupolev personnel.

3.2. *Data Quality Assurance*

Following flight 9, an HP 9000/700 series computer and a spare Metrum RS-512 tape recorder were used to assess data quality, following the process outlined in Section 5.1. Data tapes recorded during test flights with acoustic and vibration data were examined for data quality by narrow band spectral analysis. Data quality was generally found to be very good with a few exceptions. Also, relevant data from the PCM data stream (see reference [1]) were inspected mainly to ensure that the desired flight conditions were reached and held constant during the data acquisition time interval. The following problems were found and corrected in subsequent flights:

- Engine speed varied too much during some conditions of flight 9.
- Occasionally, the gain settings on the Metrum recorder were inappropriate so that the signal was too high in level causing the measurement to be over-ranged. This happened several times on takeoff, and once for an in-flight condition.
- When flight 10 landed it was snowing quite heavily. This probably caused moisture to enter one of the Kulite transducers. Subsequent freezing rendered it nonfunctional. This was discovered during post-flight calibration. The flight data itself looked fine. The transducer was replaced following the flight.
- The flight 9 spectra of signals from Kulite transducers in the front part of the cabin exhibited very strong tones at 400 Hz and many of its harmonics. The 400 Hz frequency is that of the on-board AC power supply. The problem was minimized by spatially separating the signal cables from the power supply cables.

3.3. *Ground Measurements*

3.3.1. *Ground Runups*

Ground runup data with the aircraft stationary was obtained for the following conditions:

- All engines idling, air conditioning on

- All engines idling, air conditioning off
- Three engines idling, engine 3 at full power without afterburner
- Three engines idling, engine 3 at almost full power with afterburner
- Three engines idling, engine 4 at full power without afterburner
- Three engines idling, engine 4 at almost full power with afterburner

The detailed procedures used appear in Appendix D. Because the engines could not be run at full power for more than about 20 seconds many repeat runups had to be performed in order to set gains and record on both banks of transducers. These tests, including pre-test activities, were conducted jointly by the authors and Tupolev.

3.3.2. Reverberation Time

For impulsive sound sources, we were prepared to use either toy balloons or a starter pistol. It turned out that we needed the higher intensities provided by the starter pistol. Inspection of the signals' time histories right after they were recorded showed them to exhibit the expected exponential decay behavior. Reverberation times were measured in the front and mid parts of the cabin, and in the rear instrumentation compartment. None were measured in the cockpit. Measurement procedure details are provided in Appendix E. A listing of reverberation time measurements is provided in Table 11.

Previous experience had shown that it is very difficult to determine room absorption in an aircraft passenger cabin by measuring reverberation time because that time is very short due to the large room absorption, and much of the interior space is dominated by direct sound fields radiated from fuselage walls, as opposed to the reverberant field. The TU-144LL, however, had no passenger interior - no seats and no carpeting. The floor consisted mostly of bare painted wood. The fuselage walls were covered with insulation and trim. The chances of obtaining useful reverberation time calculations were therefore quite good. These tests, including pre-test activities, were conducted jointly by the authors and Tupolev.

Table 11: Reverberation time measurement details.[7]

General Area	Run No.	Duration (s)	Shot at Tape Block #	Comments
Front Cabin	R1	5.70	~2462	Pistol: Front left corner, half height. Microphones 2 & 3 as in flight.
	R2	4.10	~2890	
	R3	3.65	~3390	Pistol: Front left corner, half height. Microphone 2 at centerline, microphone 3 as in flight
	R4	3.78	~3838	
	R5	2.11	~4247	Pistol: 3 windows in front of window blank 2, near floor; Microphones 2 & 3 as in flight.
	R6	2.62	~4371	
	R7	2.62	~4605	Pistol: same as R5/R6. Microphone 2 as in flight, microphone 3 centerline
	R8	2.18	~4737	
Mid-Cabin	R9	3.10	~4932	Pistol: Port side on floor near bulkhead near microphones 4,5,6. Microphones 4,5,6 as in flight.
	R10	3.33	~5282	
	R11	2.43	~5512	Pistol: Starboard side, 2 windows behind window blank 5 on floor. Microphones 4,5,6 as in flight.
	R12	2.37	~6529	
Rear Instr. Comp.	R13	2.11	~7769	Pistol: Front, floor, port side. Microphones 7 & 8 as in flight.
	R14	1.79	~7953	
	R15	1.86	~8051	Pistol: Front, floor, port side. Microphone 7 as in flight, microphone 8 22-in. from ceiling.
	R16	1.66	~8183	

[7] All reverberation time data collected on data bank B (see Table 7).

4. Test Points

Flight test points were chosen to cover much of the TU-144's flight envelope, as well as to obtain as large a unit Reynolds number range as possible at various Mach numbers: takeoff, landing, six subsonic cruise conditions, and eleven supersonic conditions up to Mach 2 (see Table 12). Continuous data was acquired at each test condition and designated with a unique run number. Figure 26 shows the test points in relation to the TU-144LL's flight envelope.

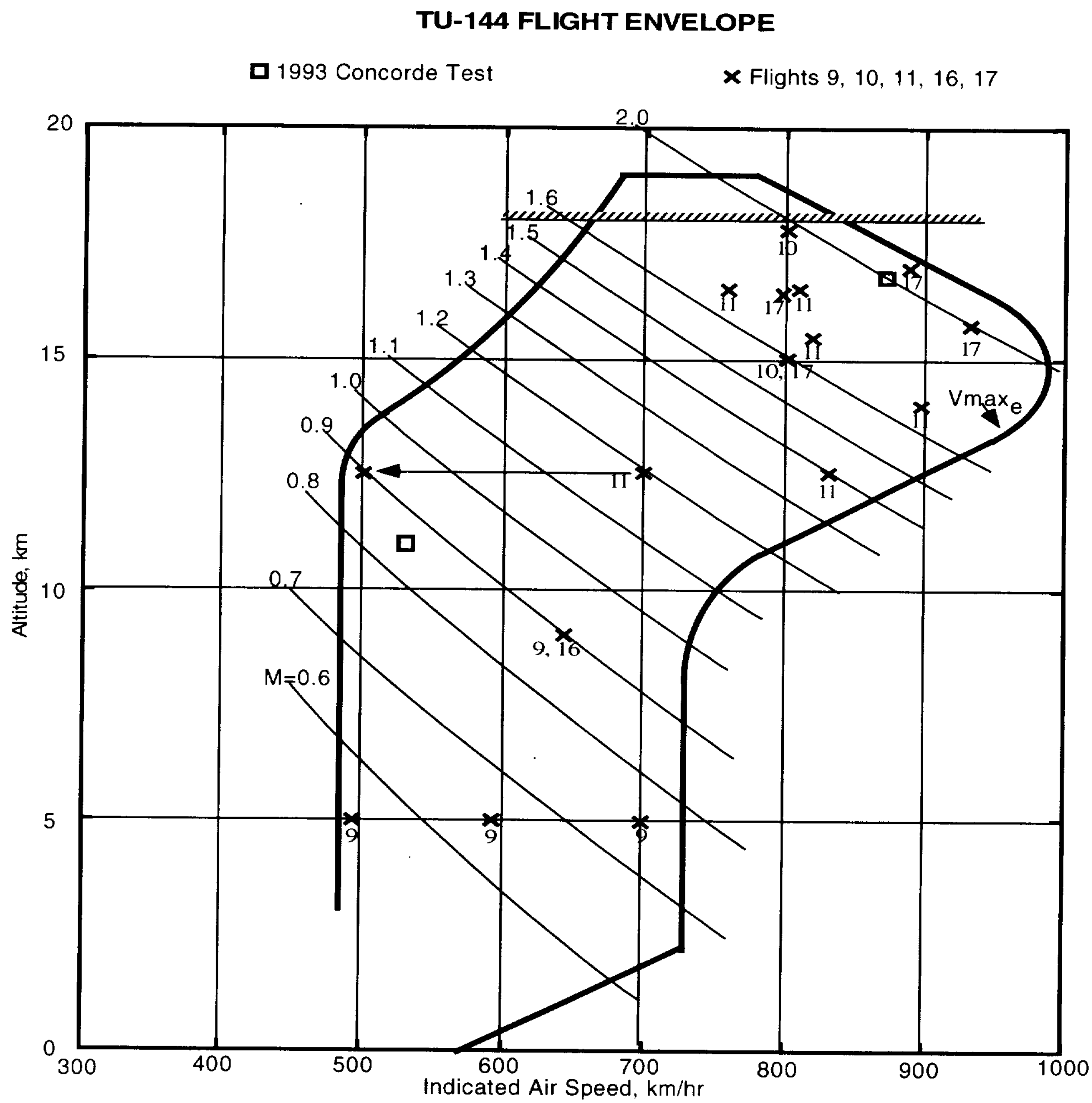


Figure 26: Tu-144 flight envelope and experiment 2.1 test points

Table 12: Table of test points.

Test Point	Run No.	Date	Data Bank	Flight No.	Altitude (km)	Altitude (kft)	Mach No. or V_{ind}	Time (GMT)	Duration (s)	Notes	Comments
	1	29-Sep-97	A		0.0	0.0	0	12:34:47	60.40		Ground runup cond. G1
	2		B					12:38:09	60.27		
	3		A					12:43:41	60.30		Ground runup cond. G2
	4		B					12:46:57	60.26		
	5		A					13:03:00	60.16		Ground runup cond. G3
	6		B					13:05:38	60.59		
	7		B					13:09:06	18.62	(^)	Ground runup cond. G4
	8		A					13:11:47	19.38		
	9		A	•				13:36:46	60.51		Ground runup cond. G5
	10		B					13:39:02	60.10		
	11		A					13:43:03	13.25		Ground runup cond. G6
	12		B					13:45:35	17.25		
FLIGHT 9											
	13	8-Oct-97	A	9	0.0	0.0	0	09:13:59	32.24		Ground runup
2.1-12	14		A		< 0.5	< 1.64		09:24:28	~74	(*)	Takeoff
2.1-9	15		A		5.0	16.4	700 km/hr	09:47:28	~45	(*)	Subsonic
	16		B					09:50:51	60.83		
2.1-10	17		A		5.0	16.4	600 km/hr	09:53:28	62.02		
	18		B					09:55:30	42.48		

Test Point	Run No.	Date	Data Bank	Flight No.	Altitude (km)	Altitude (kft)	Mach No. or V_{ind}	Time (GMT)	Duration (s)	Notes	Comments
2.1-11	19	8-Oct-97	A	9	5.0	16.4	520 km/hr	10:00:33	60.70		
	20		B					10:02:28	64.14		
	21		A		9.0	29.5	640 km/hr	10:19:25	60.11		
	22		B					10:24:02	60.10		
	23		A		4.0	13.1	550 km/hr	11:13:22	52.59		
	24		B					11:15:25	62.21		
2.1-13	25		A		< 0.5	< 1.64		11:41:16	60.02		Landing
FLIGHT 10											
	27	29-Oct-97	B	10	0.0	0.0	0	10:43:07	68.67		Ground runup
2.1-12	28		A		< 0.5	< 1.64		12:04:09	~61	(*)	Takeoff
	29		A		13.7	44.9	1.6	12:24:48	61.90		
	30		B					12:27:38	60.85		
	31		A		14.2	46.6	1.6	12:31:00	61.10		
	32		B					12:36:24	60.70		
2.1-2	33		A		16.9	55.4	1.95	12:59:05	60.13		
	34		B					13:02:56	61.82		
2.1-1	35		A		17.3	56.8	1.95	13:09:24	60.94		
	36		B					13:15:00	61.18		
	37		B					13:18:11	61.15		
2.1-13	38		A		< 0.5	< 1.64		13:51:16	60.08		Landing

Test Point	Run No.	Date	Data Bank	Flight No.	Altitude (km)	Altitude (kft)	Mach No. or V_{ind}	Time (GMT)	Duration (s)	Notes	Comments
FLIGHT 11											
2.1-12	39	14-Nov-97	A	11	< 0.5	< 1.64		09:14:15	65.22		Takeoff
2.1-2	40		A		16.0	52.5	1.8	09:39:48	57.98		
	41		B					09:49:50	60.51		
2.1-3	42		A		16.6	54.5	1.7	10:09:37	61.12		
	43		B					10:11:53	60.75		
2.1-4	44		A		15.5	50.9	1.7	10:16:59	61.02		
	45		B					10:18:48	60.88		
2.1-5	46		A		14.2	46.6	1.7	10:23:48	61.60		
	47		B					10:25:42	60.72		
2.1-6	48		A		12.6	41.3	1.4	10:31:34	60.02		
	49		B					10:33:25	63.71		
2.1-7	50		A		12.5	41.0	1.2	10:37:26	60.53		
	51		B					10:39:13	60.21		
2.1-8	52		A		12.5 - 9.8	41.0 - 32.2	1.2 - 0.9	10:42:04	60.11		Transonic
2.1-9	53		A		5.0	16.4	0.75	10:53:14	60.46		
	54		B					10:55:08	61.54		
2.1-13	55		B		< 0.5	< 1.64	0	11:06:05	59.26		Landing
FLIGHT 15											
	56	19-Dec-97	B	15	0.0	0.0	0	09:48:30	64.74		Ground runup
2.1-12	57		B		< 0.5	< 1.64		10:04:19	62.74		Takeoff

Test Point	Run No.	Date	Data Bank	Flight No.	Altitude (km)	Altitude (kft)	Mach No. or V_{ind}	Time (GMT)	Duration (s)	Notes	Comments
FLIGHT 16											
	26	22-Jan-98	B	16	0.0	0.0	0	09:44:21	57.04		Ground runup
	58		B		< 0.5	< 1.64		09:57:53	56.59		Takeoff
	59		A		9.0	29.6	640 km/hr	10:29:10	61.14		Subsonic, Angle of Attack
	60		B					10:31:59	63.09		
	61		A					10:37:53	61.81		
	62		B					10:40:31	56.02		
	63		B		< 0.5	< 1.64		11:57:52	60.02		Landing
FLIGHT 17											
	64	29-Jan-98	B	17	0.0	0.0	0	10:28:58	~56	(*)	Ground runup
	65		B		< 0.5	< 1.64		10:40:49	59.98		Takeoff
	66		A		16.2	53.2	2	11:03:53	61.39		
	67		B					11:09:48	61.12		
	68		A		16.9	55.4	2.05	11:30:50	60.64		
	69		B					11:37:55	60.58		
	70		A		16.4	53.8	1.75	11:51:26	61.28		
	71		B		15.0	49.2	1.6	11:53:06	62.70		
	72		B		< 0.5	< 1.64		12:39:55	60.16		Landing

(^) See Table 13 for description of ground runup conditions

(*) Not included in final data set.

Table 13: Ground runup conditions.

Condition	Description	Air Conditioning
G1	All engines idling	ON
G2	All engines idling	OFF
G3	Engine 3 at 72% (max thrust without afterburner), engines 1,2,4 idling	OFF
G4	Engine 3 at 98% (almost max thrust with afterburner) , engines 1,2,4 idling	OFF
G5	Engine 4 at 72% (max thrust without afterburner), engines 1,2,3 idling	OFF
G6	Engine 4 at 98% (almost max thrust with afterburner) , engines 1,2,3 idling	OFF

On 18-Nov-97, reverberation time measurements were taken in the TU-144LL passenger cabin and in the rear instrumentation compartment. Details are in Section 3.3.2.

5. The Data

5.1. Data Reduction Process

The data reduction process is depicted in Figure 27. Flight test data was recorded on two systems: the Damien PCM System and the experiment 2.1 data acquisition system described in this report.

In order to analyze the time history data recorded on the Metrum, it was necessary to download the digital data from Metrum tape. A physical connection was established between the Metrum HSDO port and an R.C. Electronics DTI-512 interface board installed in a HP 9000/700 series computer. For each run, a two step process was required to dump the data to the computer. In the first step, a multiplexed data file was created on the computer using the R.C. Electronics DTI-512 program. This file contained all channels of data between the beginning and ending blocks indicated on the manually recorded flight data sheets. In the second step, the multiplexed file was split into several files (each with one channel of data) and written in a MATLAB readable format, as prescribed in Section 5.3. Unfortunately, because the first step did not provide adequate error checking, it was possible to have corrupted data files. Typical data file errors included dropouts and crossing of channels. It was therefore necessary to manually check each channel of data to ensure that the data was downloaded from tape without error. This was a labor intensive process. After verification, the data files were archived to CD-R as specified in Section 5.3.

Microphone and Kulite calibration data were reduced in the same fashion as the time history data. Each calibration record was typically 30 seconds in length. Kulite phase calibration data was archived but not otherwise processed. Time histories of microphone and Kulite magnitude data were also archived, but additionally were analyzed to determine sensitivities in Pascals per volt. These were manually entered into calibration data files (along with accelerometer sensitivities) in a form specified in Section 5.4. Use of the calibration data files, time history data files and customized MATLAB m-files allowed for time series, auto- and cross-spectrum (narrow and 1/3 octave, with and without A-weighting), auto- and cross-correlation, transfer function and coherence analyses.

Reduction of auxiliary data, consisting of manual records (such as interior temperature) and flight parameters (such as Mach number and altitude) on the PCM system, utilized the NASA DFRC FDAS system as described in [1]. Auxiliary data files were generated with the format specified in Section 5.5. Auxiliary data was provided to serve as input to various boundary layer pressure fluctuation models for comparison with the data. Work on model updates can be found in reference [17].

5.2. Sample Data

- Boundary layer pressure

  Figure 28 shows a sample time history of the pressure fluctuations due to boundary layer turbulence measured by Kulite N1.1 in the center of the foremost window blank, at almost Mach 2. The corresponding spectrum appears in Figure 29. Some 400 Hz noise is visible in the figure. Figure 30 shows a spectrum of the data obtained under the same flight conditions by Kulite N7.1 in the center of the rear-most window blank.

  For comparison, Figure 31 shows the spectrum of pressure fluctuations measured by Kulite N1.1 for a subsonic condition (Mach number about 0.65). Figure 32 presents the spectrum obtained at the same time by Kulite N7.1.

- Skin vibration

  Figure 33 has a spectrum of fuselage skin panel acceleration measured from accelerometer 10.15 near the rear-most window blank, near Mach 2.

- Interior Noise

  Figure 34 shows a spectrum of interior noise as measured by microphone 7, located in the rear instrumentation compartment, approximately 1 or 2 feet behind the engine nozzle exhaust plane. Figure 35 shows the same data up to 1 kHz.

- Ground runup

  Figure 36 shows a spectrum of the pressure fluctuation measured by Kulite N7.1 during ground engine runup run G6.

- Reverb time

  Figure 37 shows a transient time record measured by microphone 4 during reverberation time experiment run R10. Reverberation times may be calculated using this data

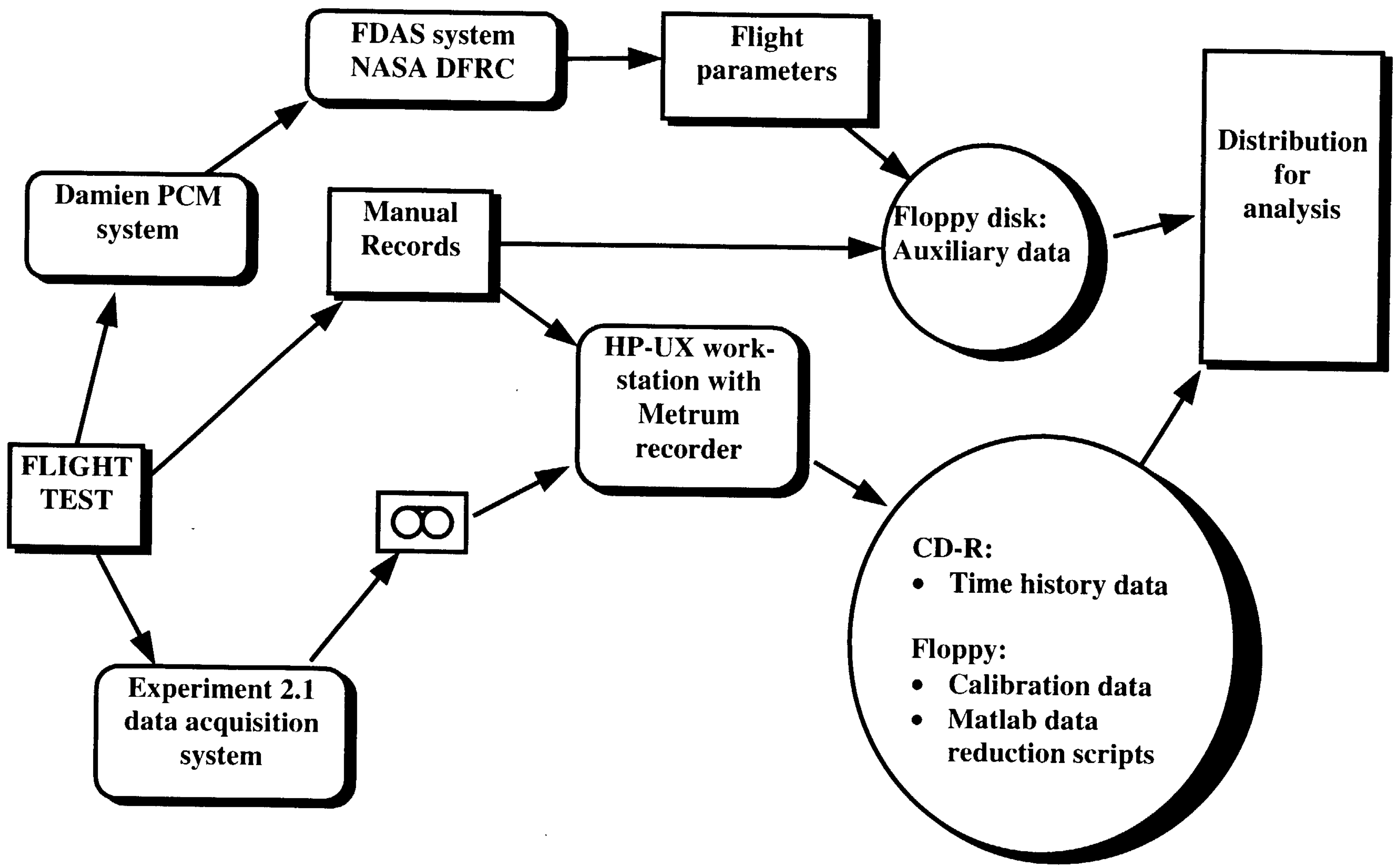


Figure 27: Data flow diagram.

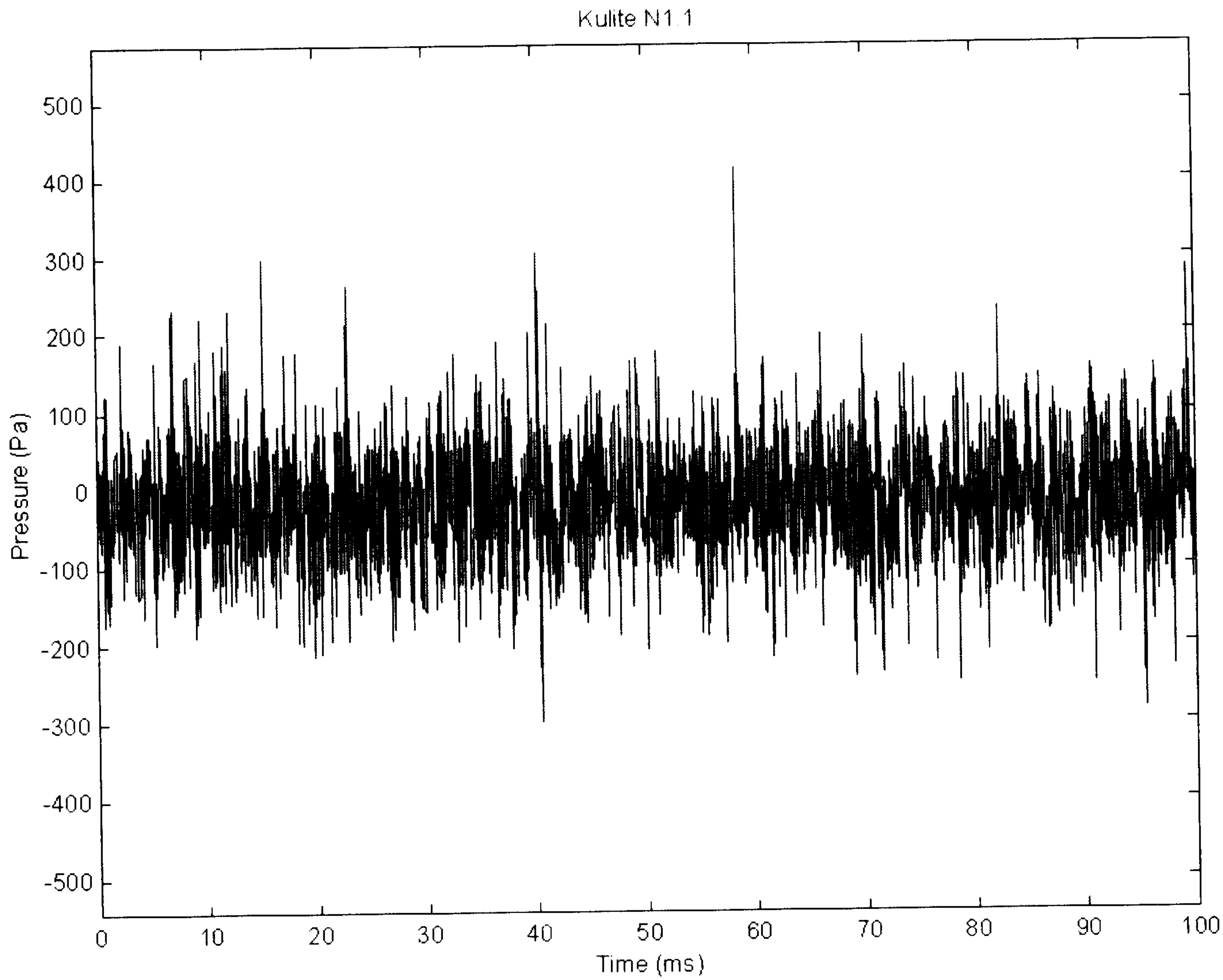


Figure 28: Sample time history of boundary layer pressure fluctuations (Kulite N1.1, Mach 1.95, Alt. 17.3km).

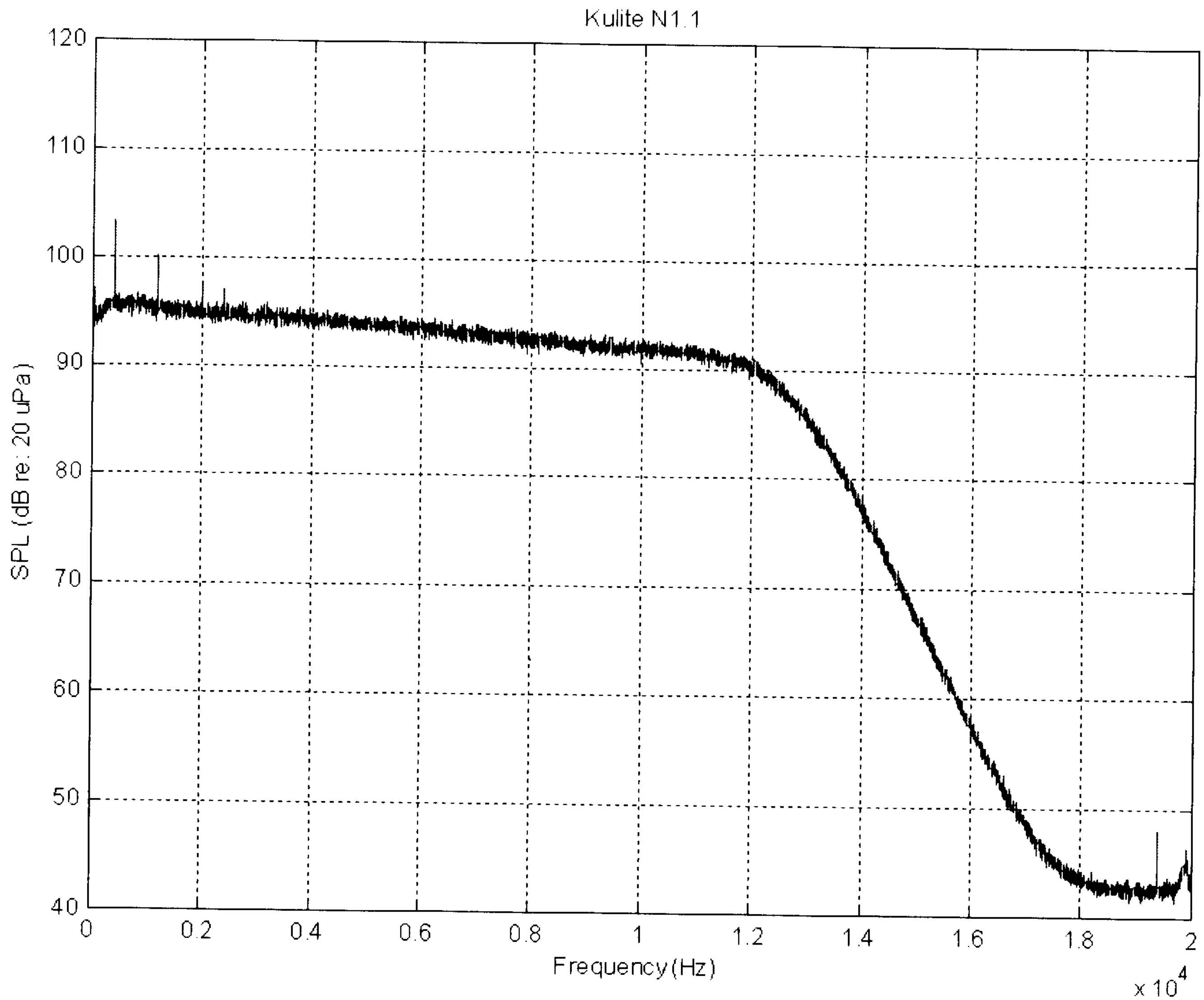


Figure 29: Narrow band spectrum of pressure fluctuations (Kulite N1.1, Mach 1.95, Alt. 17.3 km).

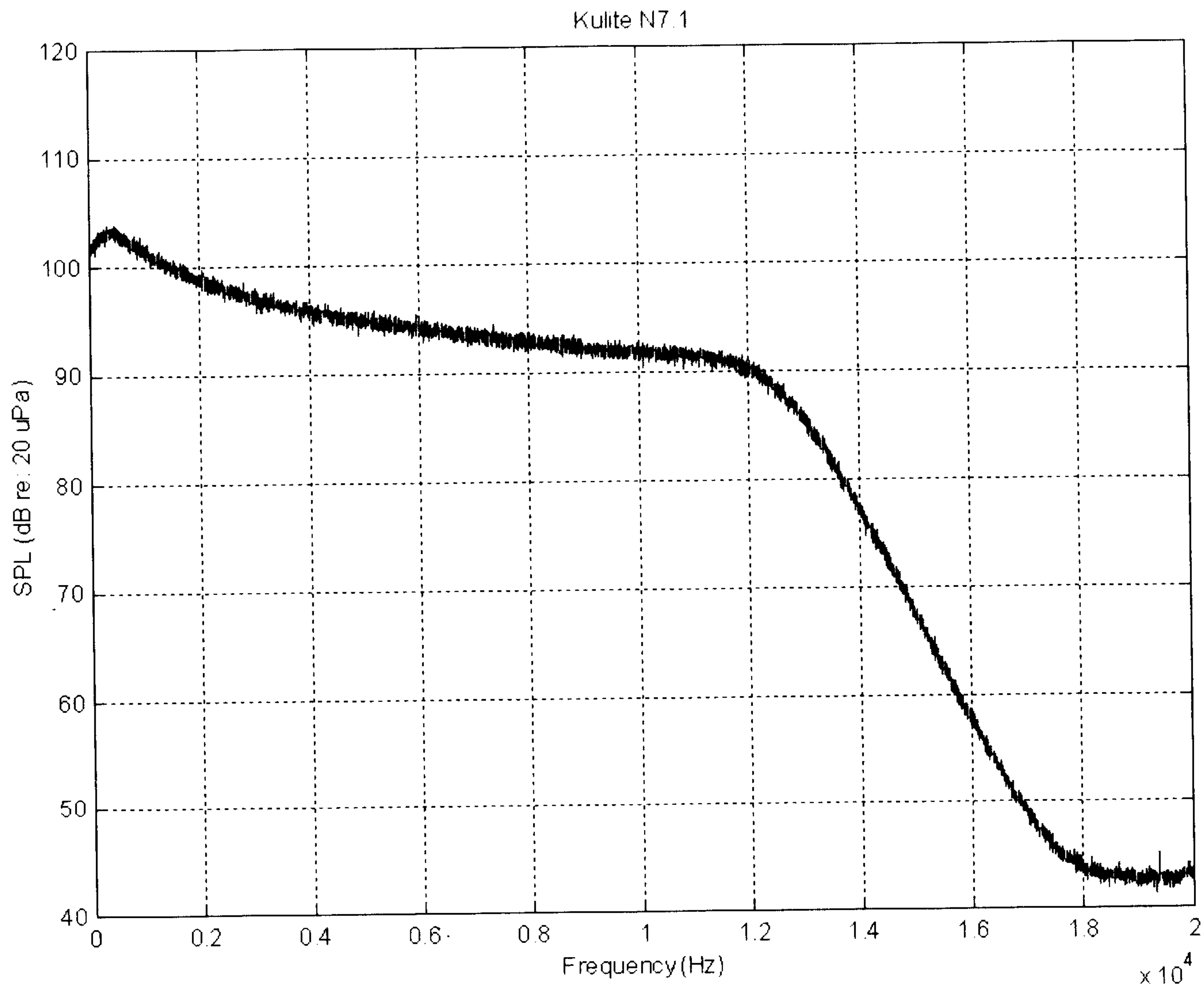


Figure 30: Narrow band spectrum of pressure fluctuations (Kulite N7.1, Mach 1.95, Alt. 17.3 km).

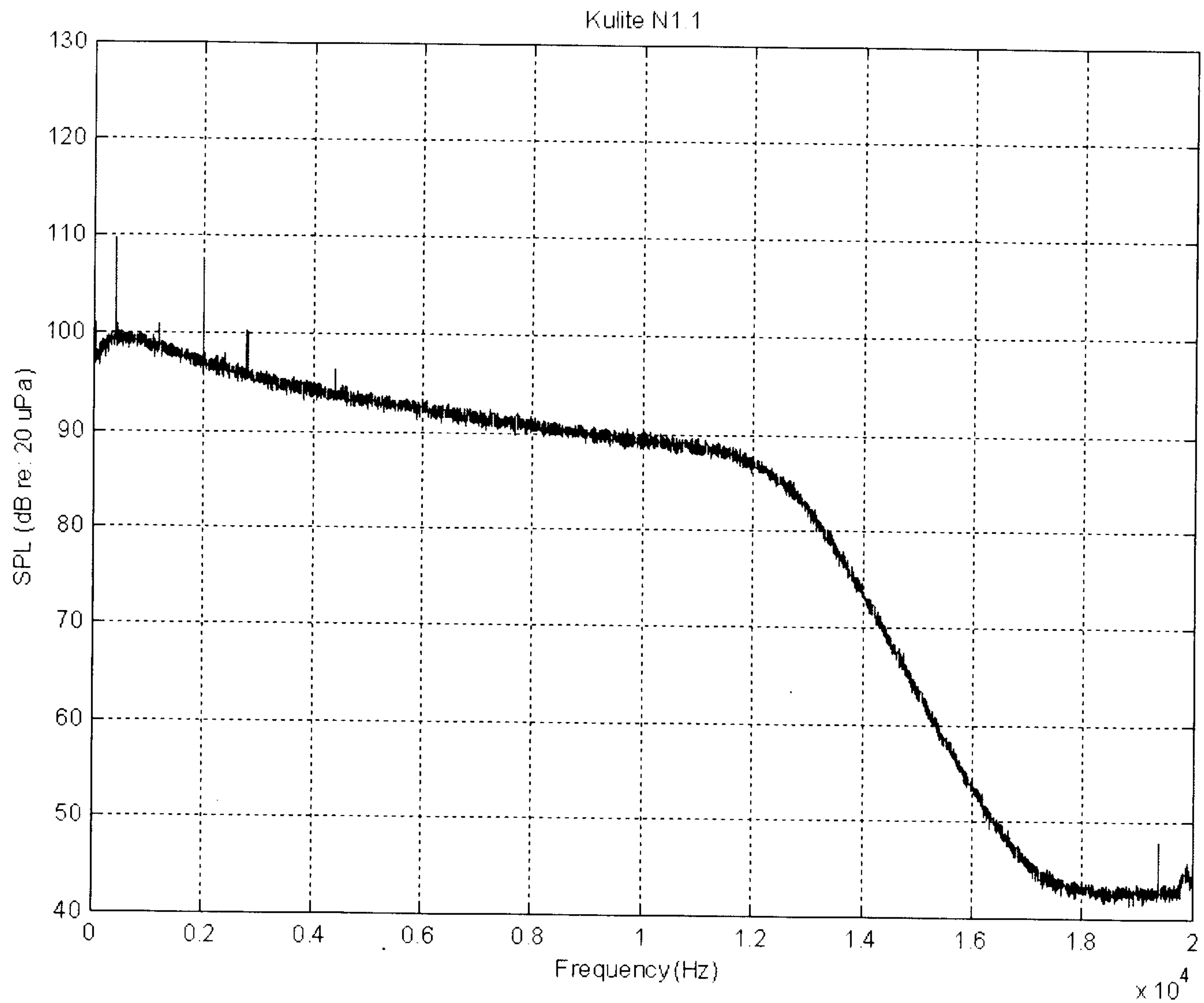


Figure 31: Narrow band spectrum of pressure fluctuations (Kulite N1.1, 600 km/h, Alt. 5 km).

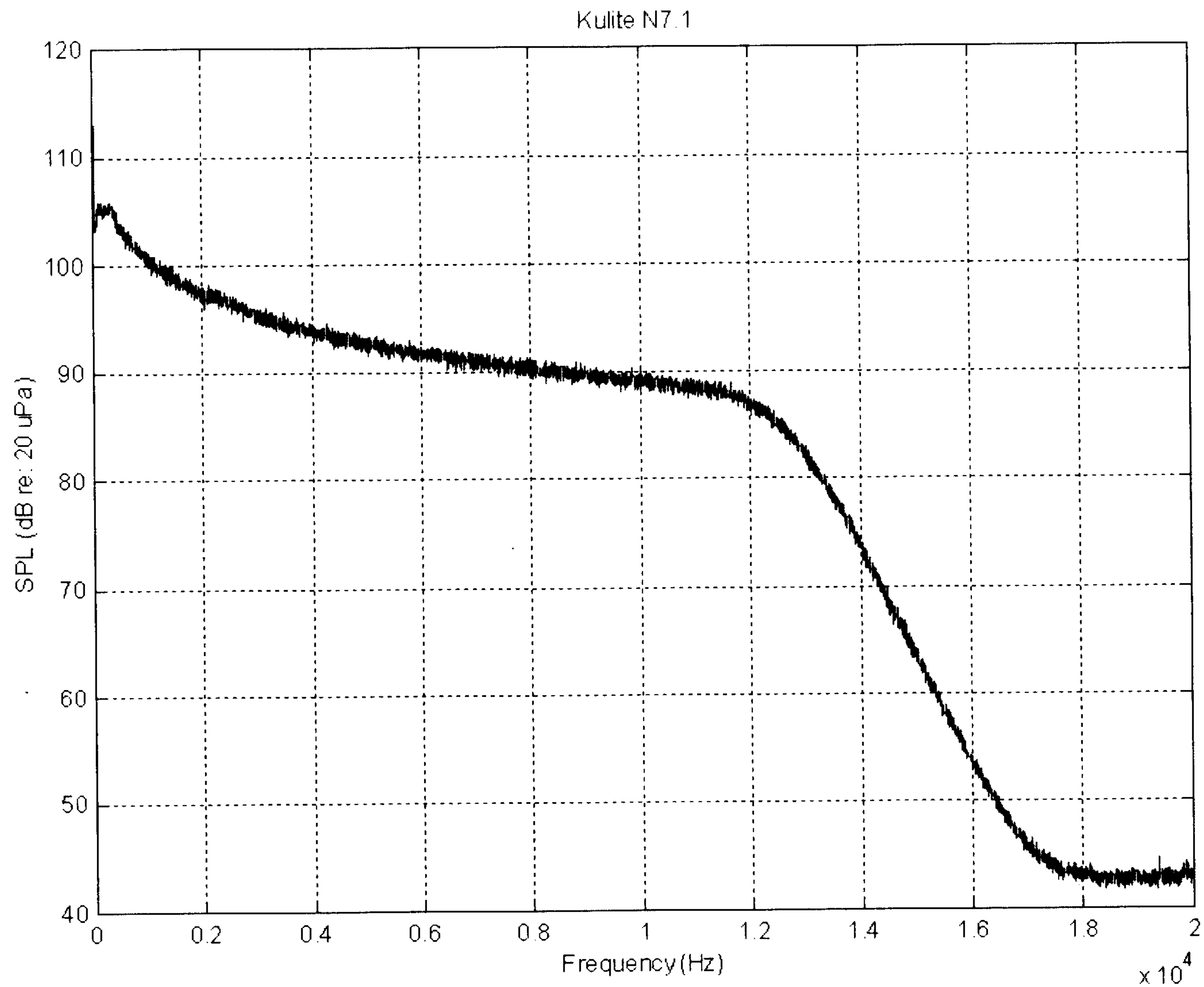


Figure 32: Narrow band spectrum of pressure fluctuations (Kulite N7.1, 600 km/h, Alt. 5 km).

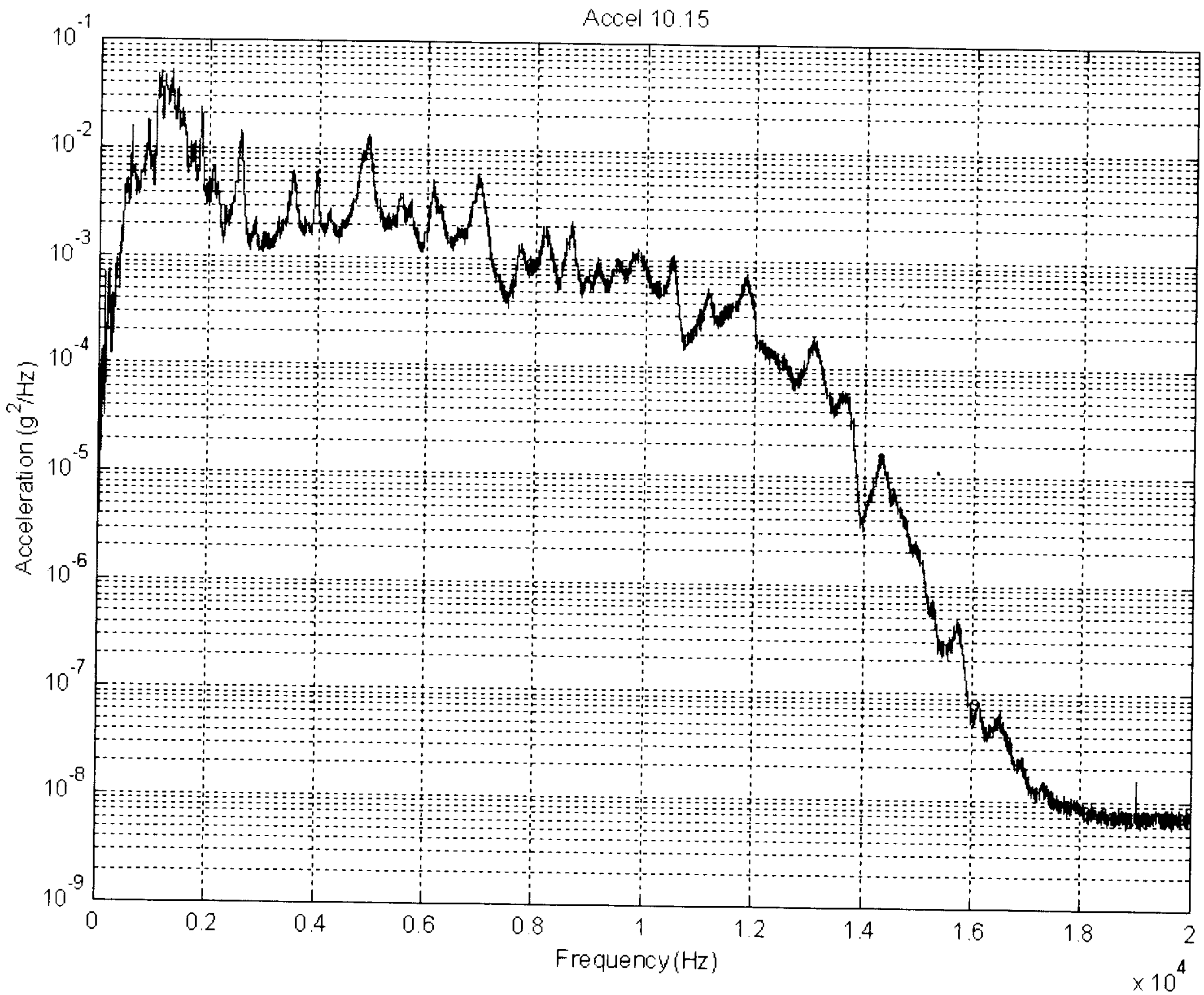


Figure 33: Narrow band spectrum of fuselage skin acceleration (Accelerometer 10.15 near Kulite N7.1, Mach 1.95, Alt. 17.3 km).

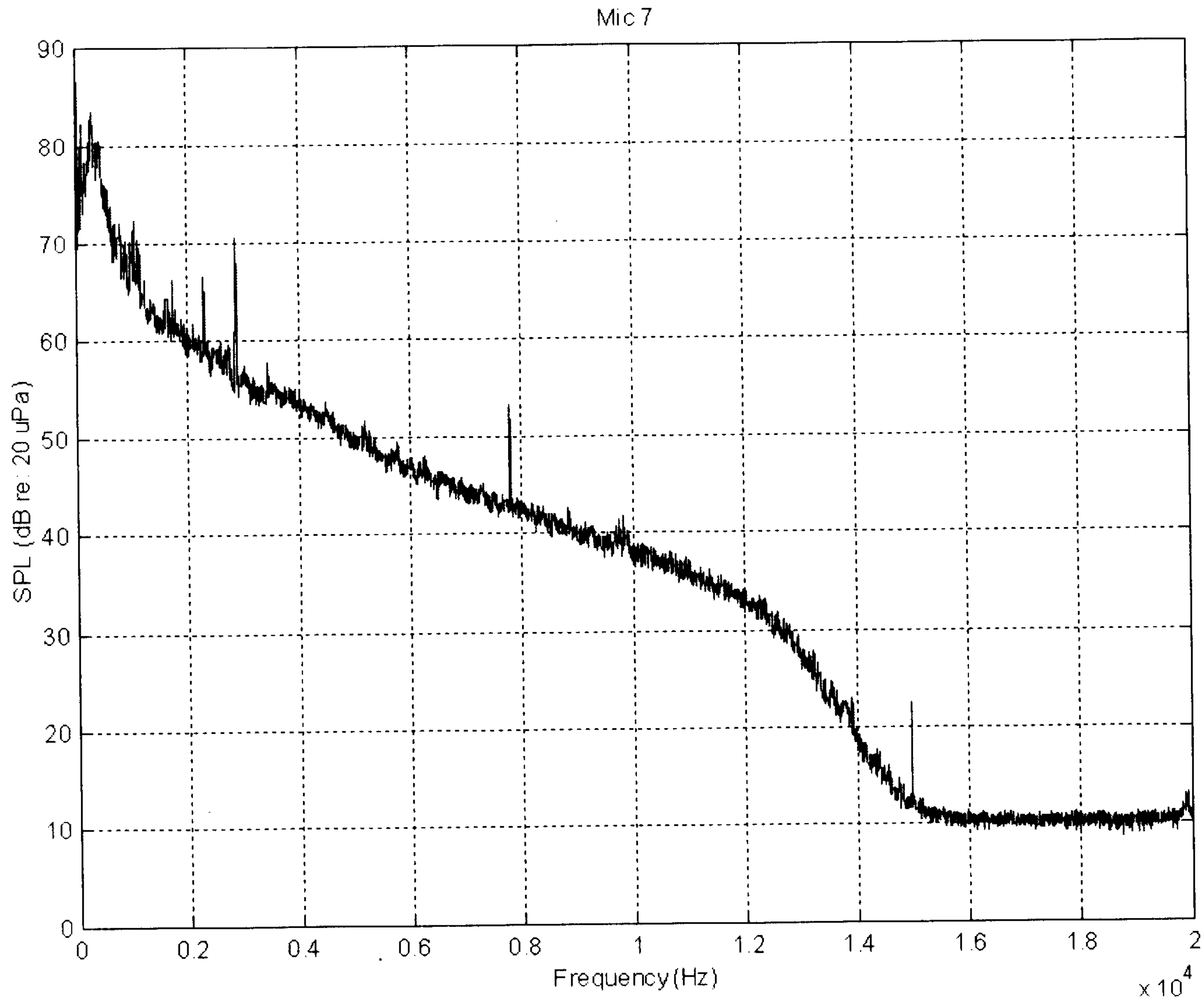


Figure 34: Narrow band spectrum of interior noise (Microphone 7 in rear instrumentation compartment, Mach 1.95, Alt. 17.3 km)

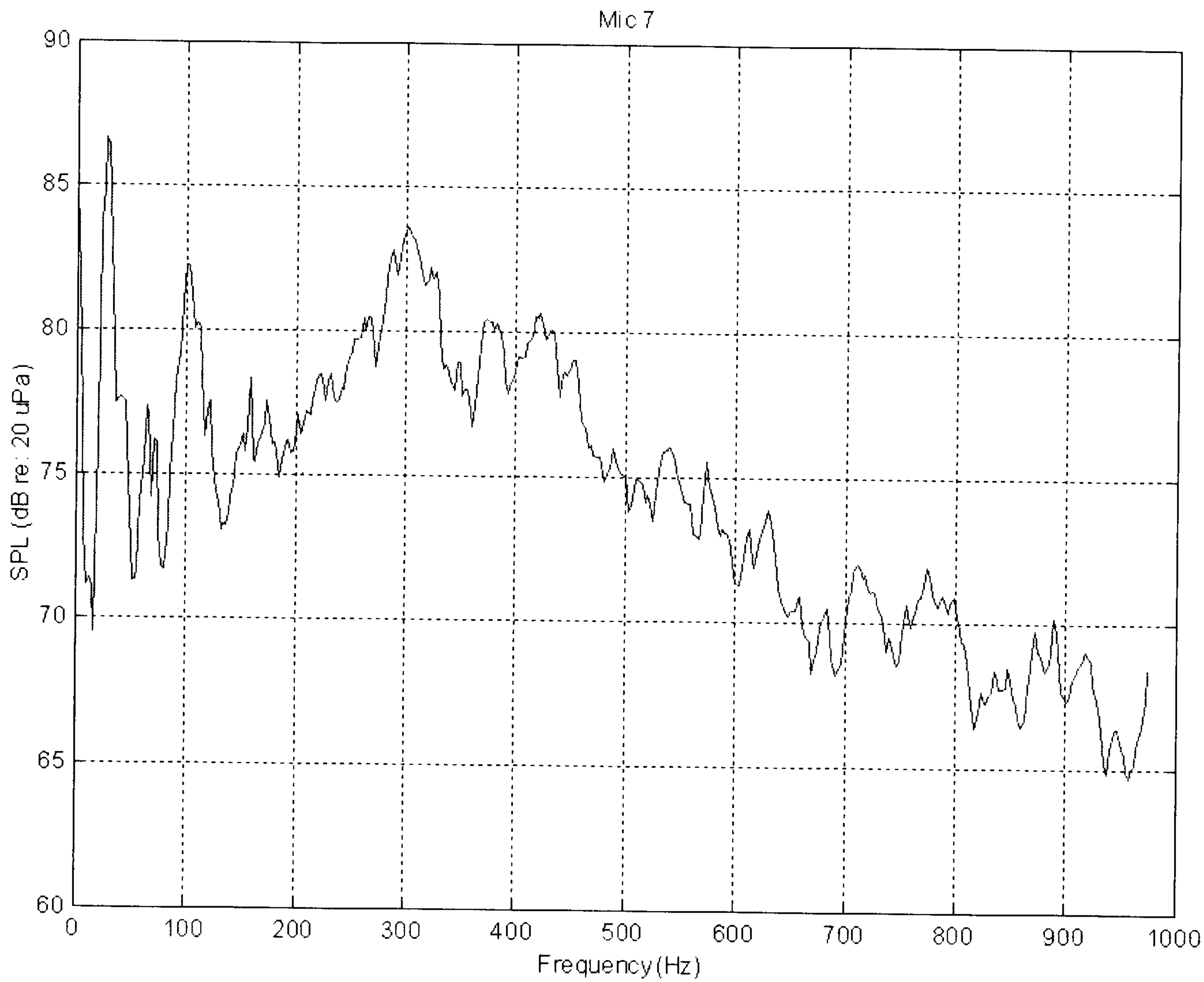


Figure 35: Narrow band spectrum of interior noise (Microphone 7 in rear instrumentation compartment, Mach 1.95, Alt. 17.3 km, Zoom on First 1000 Hz)

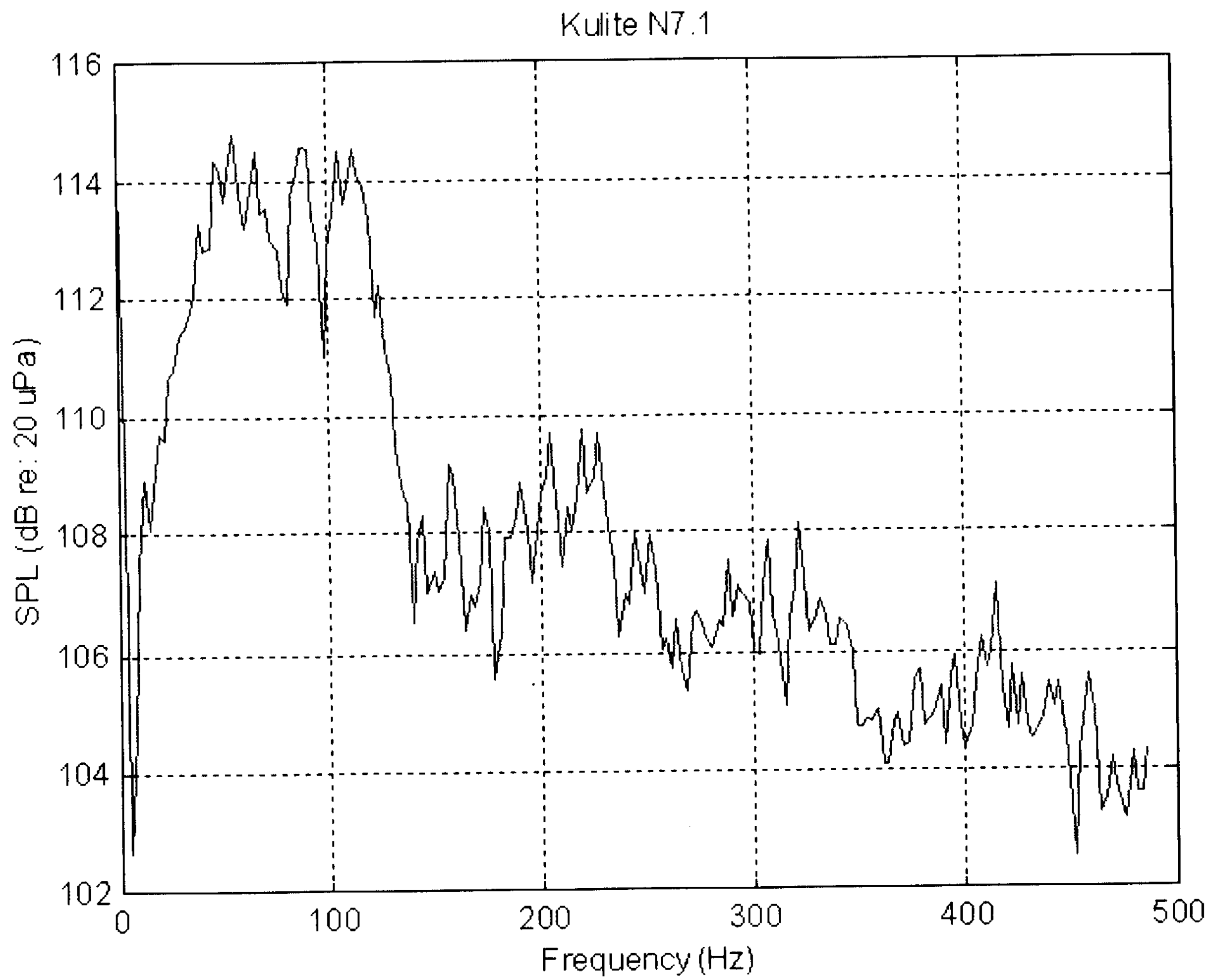


Figure 36: Ground engine runup data from run G6.

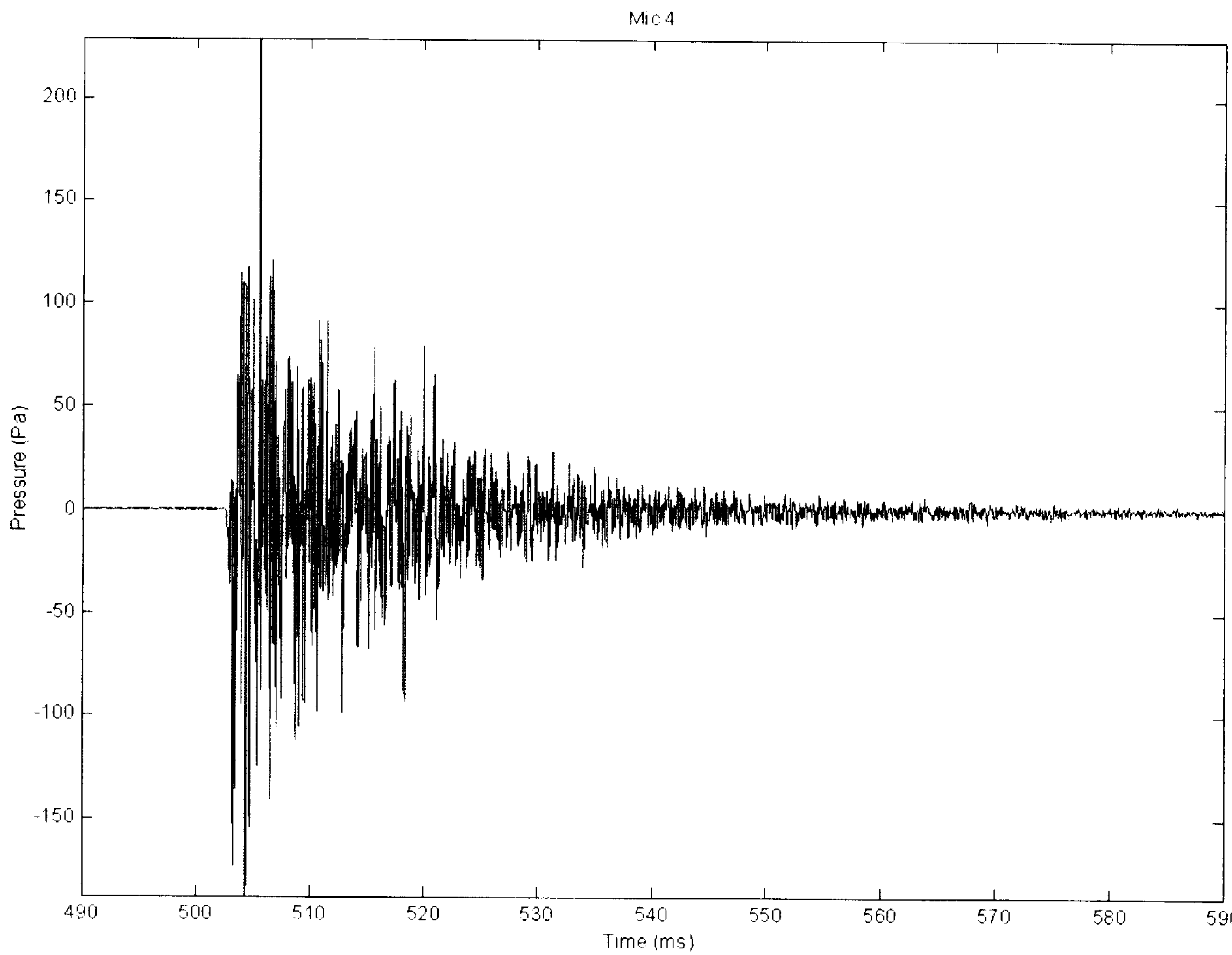


Figure 37: Sample reverberation time data (Microphone 4, Run R10).

5.3. Time History Data File Format

Time history data files were written for each channel (except IRIG-B and voice annotation channels) for each run and each flight or ground test experiment. The data files all have the same format as provided in Table 14. MATLAB variable names, which are not part of the data file but which are assigned as the data is read into MATLAB, are provided as reference.

Table 14: Format of time history data files.

MATLAB Variable Name	Data Type(*)	Number of values	Description
data.ver	float	1	Used to differentiate data file versions from one another. The present value is 1.0.
data.npt	long	1	Number of data points associated with the record. Records from the same run contain the same number of points.
(**)	long	1	Number of characters in the following string.
data.comment_line	char	(**)	Comment string used to annotate this data file.
(***)	long	1	Number of characters in the following string.
data.test_name	char	(***)	Test name field from Metrum. Because of a bug in the program used to download the data from the Metrum, this field is blank.
data.type	int	1	Data type: 1=flight, 2=engine runup, 3=calibration, 4=reverb
data.bank	int	1	1=Bank A transducers, 0=Bank B transducers
data.flight_number	int	1	Flight number.
data.run_number	int	1	Run number.
data.beg_block	int	1	Beginning Metrum block number of this record.
data.end_block	int	1	Ending Metrum block number of this record.
data.start_time.hr	int	1	Starting time (hr) of this record.
data.start_time.min	int	1	Starting time (min) of this record.
data.start_time.sec	int	1	Starting time (sec) of this record.
data.start_date.yr	int	1	Starting date (year) of this record.
data.start_date.month	int	1	Starting date (month) of this record.
data.start_date.day	int	1	Starting date (day) of this record.
data.scale	float	1	Scale factor to convert from digital counts to volts.
data.sample_rate	int	1	Data sampling rate.
data.channel	int	1	Metrum channel number.
data.time	short	data.npt	Time history record in digital counts.

(*) NOTE: The data files were written on a HP 9000/700 series computer. This is a "BIG-ENDIAN" computer, that is, the least significant byte has the most significant position in the multi-byte word. In order to read this data on a "LITTLE ENDIAN" computer, e.g. PC or DEC machine, the byte order must be reversed. MATLAB scripts provided with the data files perform any necessary byte swapping automatically depending on the computer type. In this way, the data file size is dramatically reduced in comparison to a binary MATLAB file format in which all data entries are treated as double precision floating point entries.

Data files were written in the familiar DOS 8.3 format, i.e. an 8 character prefix and 3 character extension. The file name is defined according to the convention:

Txxyyzz.MAT

where

- T = file type (f=flight, g=ground engine run-up, r=reverberation time, c=calibration)
- xx = flight or condition number, i.e. 11 for flight 11 or 06 for ground runup condition 6. (Note: For reverberation time measurements, this field is always 00).
- yy = run number from Table 12 for flight and ground engine runup data (01-72), Table 11 for reverberation time data (01-16).
- zz = data channel as specified in Table 7.

The extension used is MAT. Note that although this extension is also used to designate a MATLAB binary file format, the format used is as provided in Table 14. Efforts to read the data into MATLAB as a MATLAB binary file format will fail.

Data files were archived in ISO 9660 format on CD-R as indicated in Table 15. The 20-volume set contains all data with the exception of microphone and Kulite calibration data. Time histories of the latter are used to compute scalar calibrations which are included in the calibration data files, see Section 5.4.

Table 15: Table of CD-R titles and contents.

CD-R Title	Size (MB)	Flight No.	Run No.
G_V1	553	G1,G2	1-4
G_V2	364	G3,G4	5-8
G_V3	347	G5,G6	9-12
F9_V1	453	9	13,16-18
F9_V2	562	9	19-22
F9_V3	401	9	23-25
F10_V1	454	10	27,29,30
F10_V2	578	10	31-34
F10_V3	577	10	35-38
F11_V1	438	11	39,52,55
F11_V2	570	11	40-43
F11_V3	579	11	44-47
F11_V4	579	11	48-51

CD-R Title	Size (MB)	Flight No.	Run No.
F11_V5	289	11	53,54
F15_V1	302	15	56,57
F16_V1	564	16	26,58-60
F16_V2	422	16	61-63
F17_V1	575	17	65-67,72
F17_V2	581	17	68-71
R_V1	30	Reverb	1-16

5.4. Calibration Data File Format

For each flight or ground experiment (ground engine runup and reverberation time), a calibration data file was written into a computer file in a MATLAB data structure. A portion of a calibration data file (Flight 10) is provided below.

```
%
% THIS FILE APPLIES TO TU-144LL FLIGHT 10, CONDUCTED ON 10/29/97
%
% This file contains a portion of the data structure for each transducer.
% It contains the following:
%
%       data.xdcrstr       Character string designating the transducer
%       data.xdcr_sn       Transducer serial number
%       data.xcdr_typ      Transducer Type (1=Mic, 2=Kulite, 3=Accel, 4=Other)
%       data.precal        Pre flight cal factor in EU/V
%       data.postcal       Post flight cal factor in EU/V (same as precal if not available)
%       data.gain          Linear Gain
%       data.dbref         Reference for dB scaling
%       data.ytimstr       Character string designating the y label for time history plots
%       data.yspecstr      Character string designating the y label for auto spectra plots
%
%
switch data.channel
case 1
   data.xdcrstr    = 'Kulite N1.1';
   data.xdcr_sn    = 'I27-1';
   data.xdcr_typ   = 2;
   data.precal     = 1760.39;                % cal factor Pa/V from 150 dB data (10/21/97)
   data.postcal    = 1760.39;
   data.gain       = 1.0;
   data.dbref      = 2.0e-5;
   data.ytimstr    = 'Pressure (Pa)';
   data.yspecstr   = 'SPL (dB re: 20 uPa)';
```

In these files, information for each transducer is provided including its designation, serial number, and pre- and post-test calibration factors. Pre-test calibrations were used in place of the post-test calibrations when post-test calibrations were not performed. Only Kulite magnitude calibration data was made available in these files; phase calibrations (see Section 2.3.3) were not included here.

5.5. *Auxiliary Data File Format*

For each run, auxiliary data from the NASA DFRC FDAS system was collected into a computer file in MATLAB data structure. Here is a sample file (Flight 10, Run 35); it will be followed by further comments:

```
% This file contains auxiliary data items which exist at the "run" level:
% one parameter has a single time-invariant value for one "run" which corresponds
% to a flight condition (or an engine setting for ground runup measurements).
%
% This excludes transducer/signal channel calibration data which exist at the
% "flight" level and are stored in a different input file.
%
% Data items which end in _s are standard deviations associated with
% the parameter without _s.
%
%       RUN PARAMETERS
%       --------------
%        fdas.run.start            Start time in seconds past midnight
%        fdas.run.stop             Stop time in seconds past midnight
%
%        FLIGHT PARAMETERS
%        -----------------
%        fdas.flight.hpc           Altitude (meters)
%        fdas.flight.machc         Mach number
%        fdas.flight.ktas          True air speed (knots)
%        fdas.flight.kias          Indicated air speed (knots)
%        fdas.flight.tsc           Ambient atmospheric temperature (deg C)
%        fdas.flight.alpha         Angle of attack (deg)
%        fdas.flight.theta         Pitch angle (deg)
%        fdas.flight.beta          Side slip angle (deg)
%        fdas.flight.phi           Bank angle (deg)
%        fdas.flight.gwcalc        Gross weight (metric tons)
%
%        CABIN INTERIOR
%        --------------
%        fdas.cabin.press          Cabin pressure (mBar)
%        fdas.cabin.temp           Cabin temperature at operator location (deg C)
%
%        ENGINE PARAMETERS
%        -----------------
%        fdas.engine.rl1   Speed of low pressure spool, engine #1 (percent)
%        fdas.engine.rl2   Speed of low pressure spool, engine #2 (percent)
%        fdas.engine.rl3   Speed of low pressure spool, engine #3 (percent)
%        fdas.engine.rl4   Speed of low pressure spool, engine #4 (percent)
%        fdas.engine.rm1   Speed of medium pressure spool, engine #1 (percent)
%        fdas.engine.rm2   Speed of medium pressure spool, engine #2 (percent)
%        fdas.engine.rm3   Speed of medium pressure spool, engine #3 (percent)
%        fdas.engine.rm4   Speed of medium pressure spool, engine #4 (percent)
%        fdas.engine.rh1   Speed of high pressure spool, engine #1 (percent)
%        fdas.engine.rh2   Speed of high pressure spool, engine #2 (percent)
%        fdas.engine.rh3   Speed of high pressure spool, engine #3 (percent)
%        fdas.engine.rh4   Speed of high pressure spool, engine #4 (percent)
%        fdas.engine.v11   Vibration speed-front support engine #1 (percent)
%        fdas.engine.v12   Vibration speed-front support engine #2 (percent)
%        fdas.engine.v13   Vibration speed-front support engine #3 (percent)
%        fdas.engine.v14   Vibration speed-front support engine #4 (percent)
%        fdas.engine.v21   Vibration speed-mid support engine #1 (percent)
%        fdas.engine.v22   Vibration speed-mid support engine #2 (percent)
%        fdas.engine.v23   Vibration speed-mid support engine #3 (percent)
%        fdas.engine.v24   Vibration speed-mid support engine #4 (percent)
%        fdas.engine.v31   Vibration speed-booster chamber engine #1 (percent)
%        fdas.engine.v32   Vibration speed-booster chamber engine #2 (percent)
%        fdas.engine.v33   Vibration speed-booster chamber engine #3 (percent)
%        fdas.engine.v34   Vibration speed-booster chamber engine #4 (percent)
%
%       NOZZLE EXIT FLOW PARAMETERS - ENGINE #3
%       ---------------------------------------
```

```
%       fdas.noz3.data             Nozzle exit data exists (1=Yes, 0=No)
%       fdas.noz3.vel              Velocity (m/sec)
%       fdas.noz3.ttemp            Total temperature (deg C)
%       fdas.noz3.tpres            Total pressure (Pa)
%       fdas.noz3.mass             Mass flow rate (kg/sec)
%       fdas.noz3.area             Nozzle cross-sectional area (m^2)
%       fdas.noz3.gtemp            Exhaust gas temperature at turbine exit (deg C)
%
%       NOZZLE EXIT FLOW PARAMETERS - ENGINE #4
%       ---------------------------------------
%       fdas.noz4.data             Nozzle exit data exists (1=Yes, 0=No)
%       fdas.noz4.vel              Velocity (m/sec)
%       fdas.noz4.ttemp            Total temperature (deg C)
%       fdas.noz4.tpres            Total pressure (Pa)
%       fdas.noz4.mass             Mass flow rate (kg/sec)
%       fdas.noz4.area             Nozzle cross-sectional area (m^2)
%       fdas.noz4.gtemp            Exhaust gas temperature at turbine exit (deg C)
%
%       FUSELAGE OUTER SURFACE TEMPERATURES (LEFT SIDE)
%       -----------------------------------------------
%       fdas.otemp.t923pav         T/C forbody 15900(*)-90 deg(**) (deg C)
%       fdas.otemp.t929pav         T/C fuselage 24300-67 deg (deg C)
%       fdas.otemp.t937pav         T/C fuselage 30320-67 deg (deg C)
%       fdas.otemp.t938pav         T/C fuselage 30320-90 deg (deg C)
%       fdas.otemp.t948pav         T/C fuselage 41160-67 deg (deg C)
%       fdas.otemp.t949pav         T/C fuselage 41160-90 deg (deg C)
%       fdas.otemp.t951pav         T/C fuselage 46000-67 deg (deg C)
%       fdas.otemp.t952pav         T/C fuselage 46000-90 deg (deg C)
%       (*) Millimeters from a forward reference point
%       (**) Angle measured circumferentially from crown
%
%       RUN PARAMETERS
%       --------------
fdas.run.start            = 47364.000
fdas.run.stop             = 47424.000
%
%       FLIGHT PARAMETERS
%       -----------------
fdas.flight.hpc           = 56653.38
fdas.flight.machc         = 1.967909
fdas.flight.ktas          = 1113.779
fdas.flight.kias          = 454.9797
fdas.flight.tsc           = -62.20151
fdas.flight.alpha         = 4.923744
fdas.flight.theta         = 3.442639
fdas.flight.beta          = 1.076307
fdas.flight.phi           = -1.078853
fdas.flight.gwcalc        =   1.3606821e+02
%
%       CABIN INTERIOR
%       --------------
fdas.cabin.press          = 903
fdas.cabin.temp           = 14.9
%
%       ENGINE PARAMETERS
%       -----------------
fdas.engine.rl1    = 76.13023
fdas.engine.rl2    = 76.17246
fdas.engine.rl3    = 76.65763
fdas.engine.rl4    = 78.18011
fdas.engine.rm1    = 83.50220
fdas.engine.rm2    = 83.79623
fdas.engine.rm3    = 84.19279
fdas.engine.rm4    = 85.48249
fdas.engine.rh1    = 88.47282
fdas.engine.rh2    = 88.81432
fdas.engine.rh3    = 88.53609
fdas.engine.rh4    = 89.28443
fdas.engine.vl1    = 73.88566
fdas.engine.vl2    = 73.82329
fdas.engine.vl3    = 74.00000
```

```
fdas.engine.v14    = 75.88566
fdas.engine.v21    = 53.00000
fdas.engine.v22    = 53.06861
fdas.engine.v23    = 53.95842
fdas.engine.v24    = 54.55717
fdas.engine.v31    = 118.3971
fdas.engine.v32    = 119.0000
fdas.engine.v33    = 118.7089
fdas.engine.v34    = 119.8046
%
%        NOZZLE EXIT FLOW PARAMETERS - ENGINE #3
%        -------------------------------------
fdas.noz3.data              = 0
fdas.noz3.vel               = -888.88
fdas.noz3.ttemp             = -888.88
fdas.noz3.tpres             = -888.88
fdas.noz3.mass              = -888.88
fdas.noz3.area              = -888.88
fdas.noz3.gtemp             = -888.88
%
%        NOZZLE EXIT FLOW PARAMETERS - ENGINE #4
%        -------------------------------------
fdas.noz4.data              = 0
fdas.noz4.vel               = -888.88
fdas.noz4.ttemp             = -888.88
fdas.noz4.tpres             = -888.88
fdas.noz4.mass              = -888.88
fdas.noz4.area              = -888.88
fdas.noz4.gtemp             = -888.88
%
%        FUSELAGE OUTER SURFACE TEMPERATURES (LEFT SIDE)
%        -------------------------------------------
fdas.otemp.t923pav          = 75.403381
fdas.otemp.t929pav          = 78.318367
fdas.otemp.t937pav          = 73.808716
fdas.otemp.t938pav          = 77.145996
fdas.otemp.t948pav          = 81.295204
fdas.otemp.t949pav          = 79.684799
fdas.otemp.t951pav          = 76.595589
fdas.otemp.t952pav          = 80.901817
%
% STANDARD DEVIATIONS
% ==================
%        FLIGHT PARAMETERS
%        -----------------
fdas.flight.hpc_s           = 72.33243
fdas.flight.machc_s         = 0.3604686E-02
fdas.flight.ktas_s          = 2.260388
fdas.flight.kias_s          = 1.501028
fdas.flight.tsc_s           = 0.2854766
fdas.flight.alpha_s         = 0.4942496E-01
fdas.flight.theta_s         = 0.1651940
fdas.flight.beta_s          = 0.8170152E-01
fdas.flight.phi_s           = 0.2715641
%
%        ENGINE PARAMETERS
%        -----------------
fdas.engine.rl1_s = 0.1681500
fdas.engine.rl2_s = 0.1507661
fdas.engine.rl3_s = 0.1631295
fdas.engine.rl4_s = 0.1777662
fdas.engine.rm1_s = 0.2246118
fdas.engine.rm2_s = 0.1052996
fdas.engine.rm3_s = 0.1543996
fdas.engine.rm4_s = 0.1561846
fdas.engine.rh1_s = -999.99
fdas.engine.rh2_s = 0.2883749
fdas.engine.rh3_s = -999.99
fdas.engine.rh4_s = 0.3346474
fdas.engine.vl1_s = 0.3185205
fdas.engine.vl2_s = 0.3818473
```

```
fdas.engine.v13_s = 0.
fdas.engine.v14_s = 0.3185205
fdas.engine.v21_s = 0.
fdas.engine.v22_s = 0.2530479
fdas.engine.v23_s = 0.1997920
fdas.engine.v24_s = 0.4972551
fdas.engine.v31_s = 0.4905200
fdas.engine.v32_s = 0.
fdas.engine.v33_s = 0.4553524
fdas.engine.v34_s = 0.3967994
%
%        FUSELAGE OUTER SURFACE TEMPERATURES (LEFT SIDE)
%        -----------------------------------------------
fdas.otemp.t923pav_s        = 2.355395
fdas.otemp.t929pav_s        = 1.672243
fdas.otemp.t937pav_s        = 2.283934
fdas.otemp.t938pav_s        = 1.993614
fdas.otemp.t948pav_s        = 3.388538
fdas.otemp.t949pav_s        = 3.681047
fdas.otemp.t951pav_s        = 5.388420
fdas.otemp.t952pav_s        = 5.652197
```

Nozzle exit flow parameters are only available for ground runups. Special values -888.88 indicate that data are not available. Special values -999.99 indicate that the attempt of obtaining the value ran into an error condition, and that it was judged too time consuming to attempt to resolve the problem.

Plots of the flight data parameters on a 10-second interval are provided for each flight in Appendix G.

5.6. Data Availability

The complete time history data set is archived on a 20 volume CD-R compilation. Data processing scripts for use with MATLAB, calibration data files and auxiliary data files are on floppy disk. Time histories of the calibration file records are not available.

Requests for data should be submitted in writing to the following address:

Dr. Stephen A. Rizzi
NASA Langley Research Center
Mail Stop 463
Hampton, VA 23681-2199
Email: s.a.rizzi@larc.nasa.gov

A determination of data availability will be made on a case-by-case basis.

5.7. *Boundary Layer Thickness*

Boundary layer thickness is often required in prediction schemes of boundary layer pressure fluctuations. For reference, two sets of prediction formulas are included here. The one marked "US" is used by Boeing for interior noise prediction. The one marked "Russia" is used by Tupolev. Given quantities: Free stream Mach number M, free stream speed of sound a, free stream kinematic viscosity ν, distance from aircraft nose x.

Table 16: Formulae for boundary layer thickness calculations.

Quantity	US	Russia
True Air Speed	$U = Ma$	
Reynolds Number	$\mathrm{Re} = \frac{xU}{\nu}$	
Boundary Layer Thickness	$\delta = 0.37x\,\mathrm{Re}^{-0.2}\left[1+\left(\frac{\mathrm{Re}}{6.9\times10^{7}}\right)^{2}\right]^{0.1}$	$\delta = 0.37x\,\mathrm{Re}^{-0.2}\left(1+0.144M^{2}\right)^{0.35}$
Displacement Thickness	$\delta^* = \frac{\delta\left(1.3+0.43M^{2}\right)}{10.4+0.5M^{2}\left(1+2\times10^{-8}\,\mathrm{Re}\right)^{0.333}}$	$\delta^* = \delta\left[1-\frac{1.88(\log_{10}\mathrm{Re}-3.06)}{(1.88\log_{10}\mathrm{Re}-4.752)\times\left(1+0.065M^{2}\right)}\right]$
Momentum Thickness	$\theta = \frac{\delta}{10.4+0.5M^{2}\left(1+2\times10^{-8}\,\mathrm{Re}\right)^{0.333}}$	(no formula supplied)

Figure 38 compares the boundary layer and displacement thickness formulas graphically for various flight conditions.

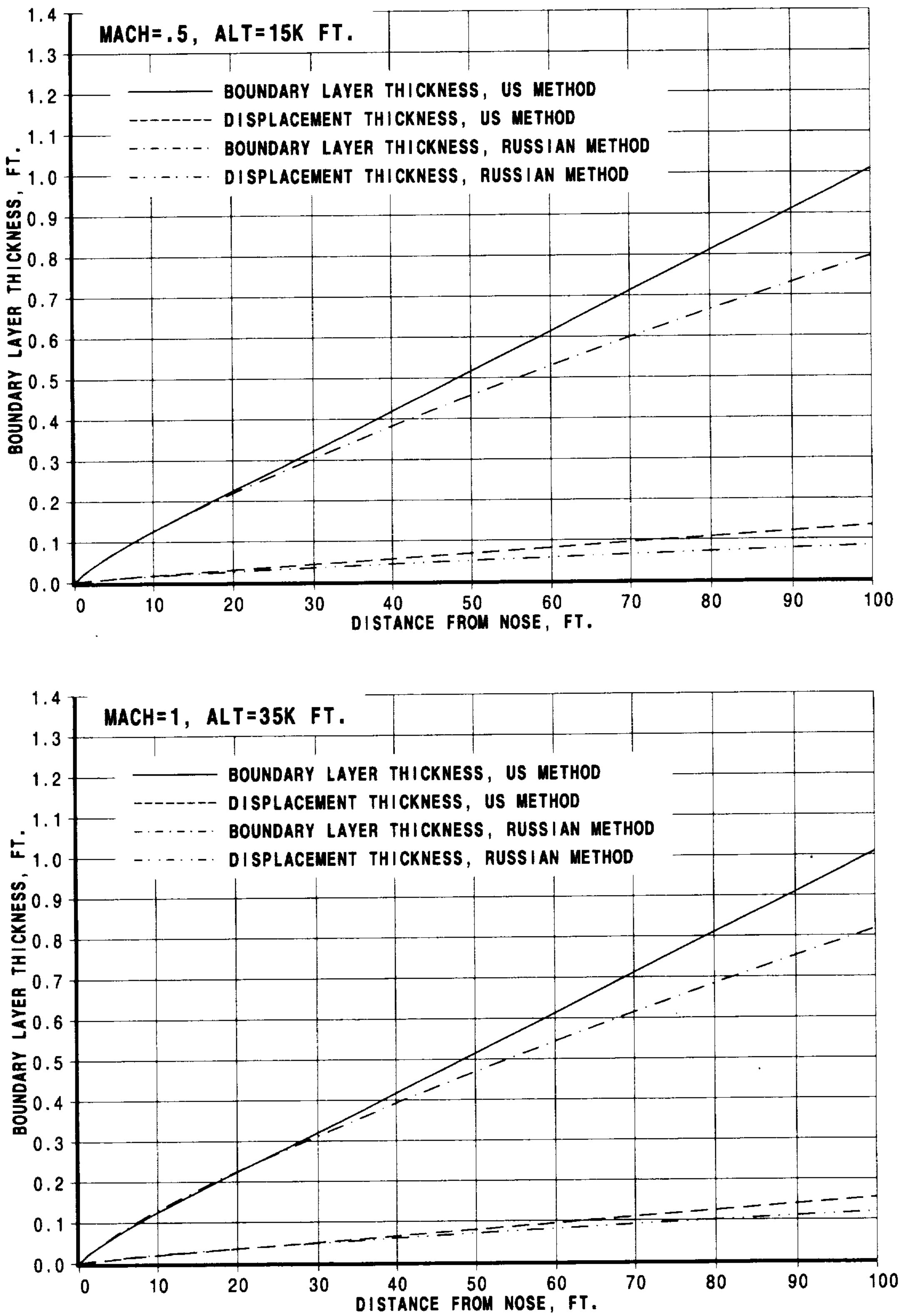
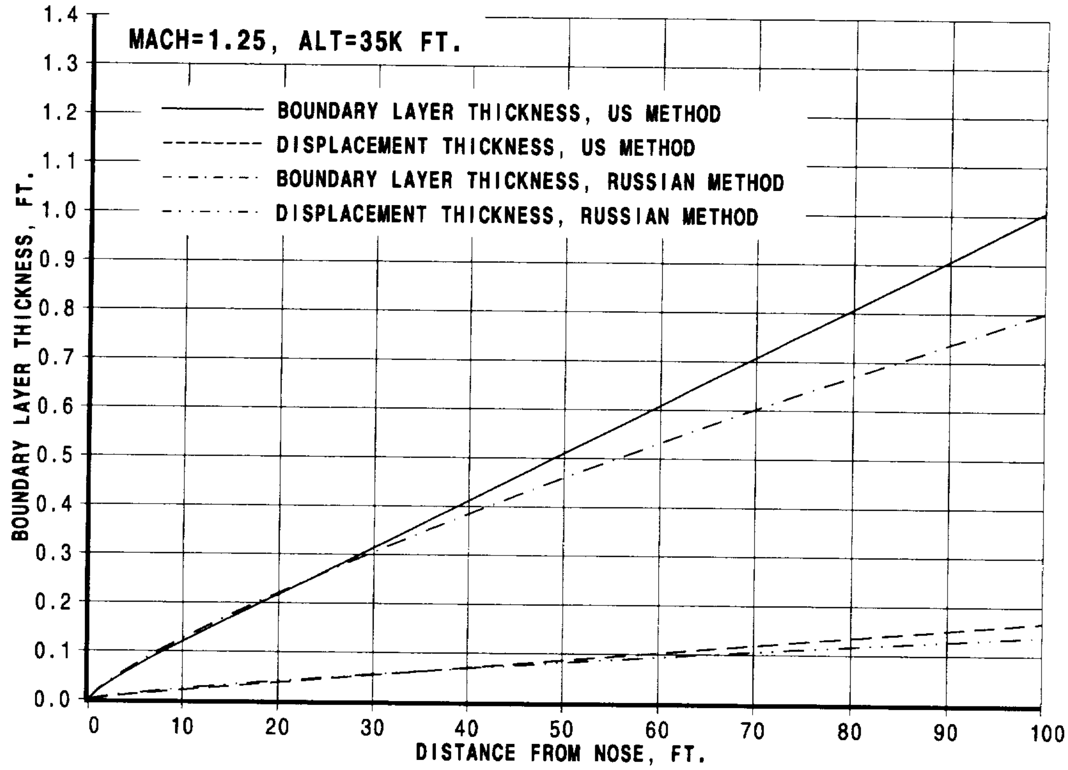


Figure 38: Comparison of boundary layer and displacement thickness calculations.



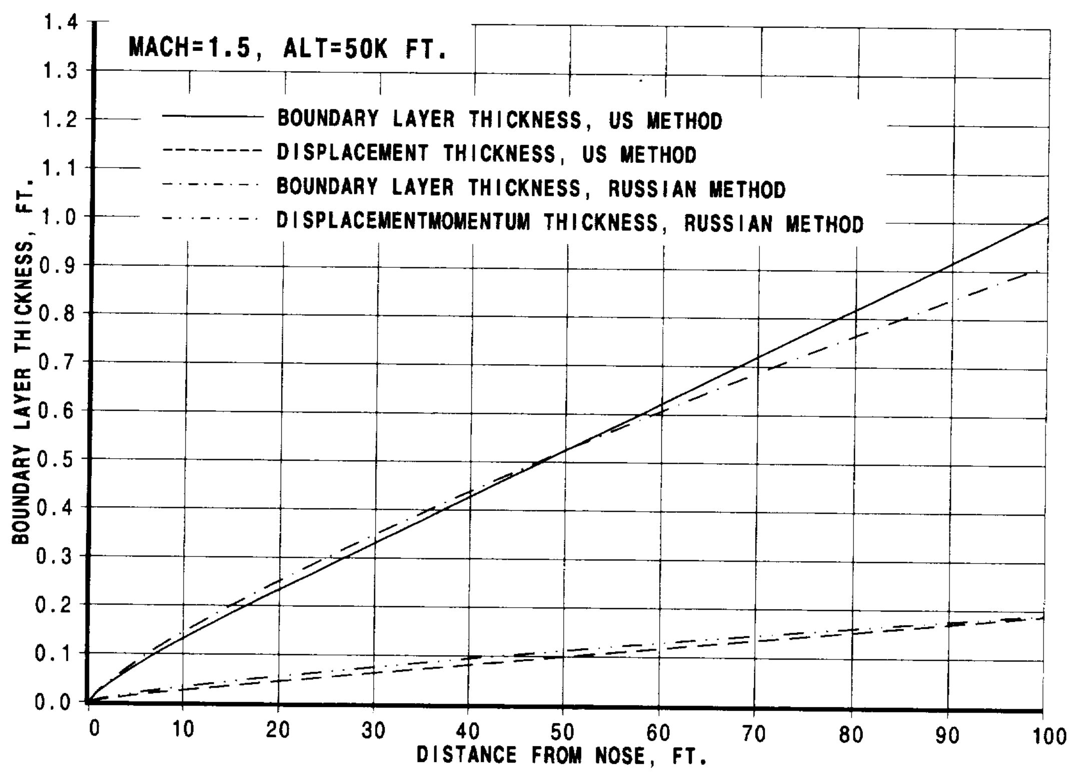
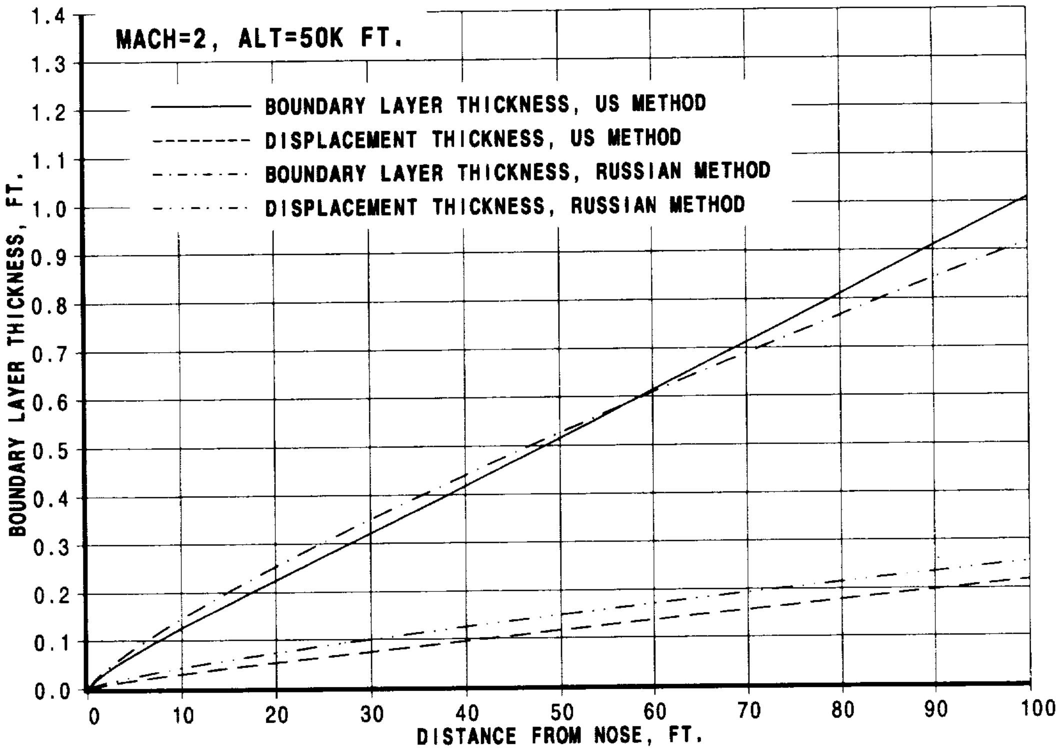


Figure 38 (continued)



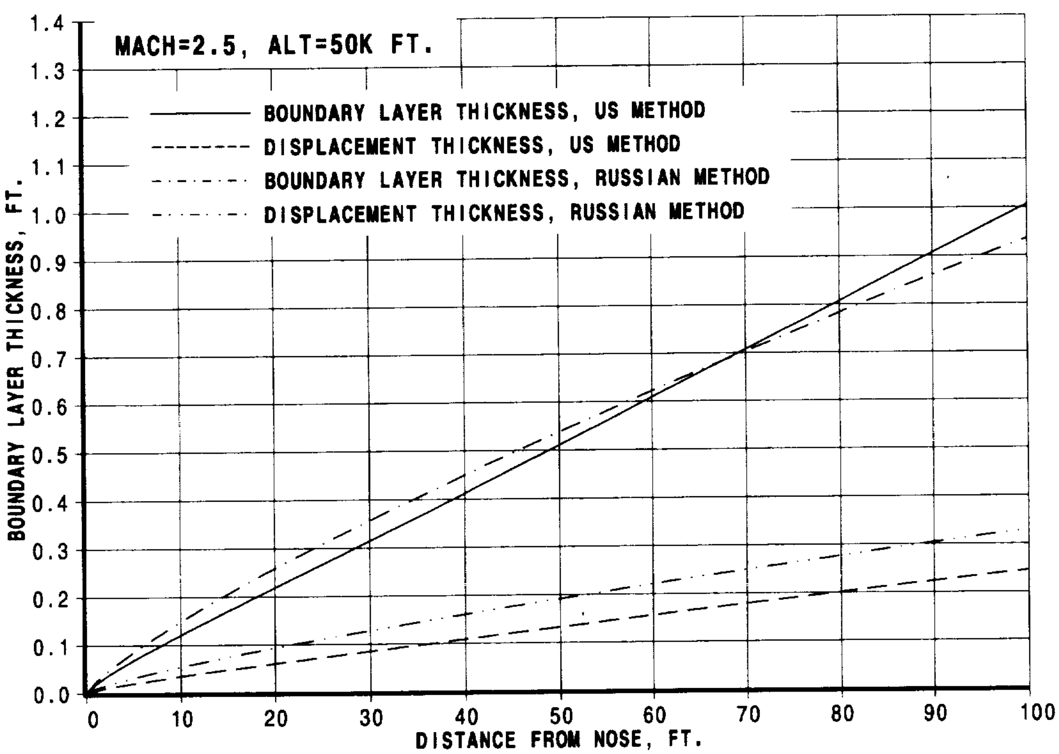


Figure 38 (continued)

6. Measurement Uncertainties

The following are the dominant sources of uncertainty: Deviation from constant test point conditions, and pressure transducer flushness.

6.1. Deviation From Constant Test Point Conditions

We cannot make a general statement regarding uncertainty in this case because the constancy of test conditions varies greatly. The reader, or user of the data, needs to assess it for each test point using the standard deviations of auxiliary data provided in MATLAB files accompanying the main data. Recordings during takeoffs and landings have large variations as one would expect. The constancy during regular flight depends on the pilot's skill in using minimum control inputs during data acquisition. Constancy improved as the test flights progressed.

6.2. Pressure Transducer Flushness

As reported in 1975 by Hanly [23], there can be a substantial deleterious effect of installing a transducer measuring turbulent surface pressure without carefully controlling the amount by which it protrudes past or is recessed into the surrounding surface. Because the Kulite transducers used in the present study have a small cavity behind the protective screen it was decided that a special investigation was needed to determine the effect of transducer flushness on measured turbulence spectra, as a function of flight condition (altitude and Mach number). If this study would show that a single transducer flushness value would not guarantee accuracy at all conditions then a method of correcting measured spectra should be provided.

This study was carried out by TsAGI [22] using the same Kulite XCS-190-15D transducer and insulating boss as used in the test flights. The window blank curvature was simulated by embedding boss and transducer into a 40-mm diameter 'hub' with a cylindrical face of appropriate radius (1600-mm). The hub was inserted into the otherwise flat wind tunnel wall. The amount of the transducer face's protrusion or recess with respect to the surrounding surface was measured optically. Transducer response measurements were made at the following flow conditions:

Mach Number	0.5	0.78	1.5	2.0	2.5
Simulated Altitude (km)	4.9	4.9	13.8	16.8	16.8

A truly flush mounted 1/8-th inch condenser microphone (Bruel & Kjaer 4138) without grid cap was used as a basis for comparison (such a microphone is not suitable for in-flight measurements due to its fragility). The data in Table 17 show the difference between levels measured by the condenser microphone and those by the Kulite where the latter was at its 'reference' or 'zero' position: the transducer face is even with the lowest part of the intersection curve of the cylindrical hole that the transducer is mounted in, and the outer cylindrical surface simulating the window blank/fuselage curvature. Specifically:

$$\Delta L_1 = L_{Kulite} - L_{B\&K\frac{1}{8}} \qquad \Delta L_2 = L_{Kulite} - \left(L_{B\&K\frac{1}{8}} + Corr_{\mathrm{Corcos}} \right)$$

where $Corr_{\mathrm{Corcos}}$ is the correction for transducer size according to [24] (only significant at higher frequencies).

Table 17: Spectral differences of pressure fluctuation measurements (dB)[8]

Freq. (Hz)	Mach Number									
	0.5		0.78		1.5		2.0		2.5	
	ΔL_1	ΔL_2	ΔL_1	ΔL_2	ΔL_1	ΔL_2	ΔL_1	ΔL_2	ΔL_1	ΔL_2
25	0.2		-0.2		0.2		*		0.2	
31.5	*		*		*		-0.2		*	
40	*		-0.2		*		*		0.2	
50	*		0.2		*		0.2		*	
63	-0.3		*		0.2		*		*	
80	*		*		-0.2		*		*	
100	*		*		*		-0.2		*	
125	*		*		*		*		*	
160	-0.2		*		*		*		-0.2	
200	0.2		*		*		*		*	
250	-0.3		*		*		-0.2		*	
315	-0.3		-0.2		*		*		0.2	
400	0.2		-0.2		*		*		-0.2	
500	0.2		*		*		*		*	
630	-0.3		*		*		*		0.2	
800	*	*	-0.3		*		0.2		*	
1000	*	-0.2	-0.2		*		*		-0.2	
1250	*	-0.2	-0.5	-0.6	*		*		0.2	
1600	-0.2	-0.5	-0.5	-0.6	*	*	*		-0.2	
2000	-0.5	-0.9	-0.6	-0.8	*	-0.2	*		*	
2500	-1	-1.5	-0.6	-0.9	*	-0.2	-0.2	-0.3	-0.2	-0.3
3150	-2.4	-3	-1.2	-1.6	-0.2	-0.4	-0.2	-0.3	*	-0.3
4000	-4.3	-5	-1.8	-2.3	-0.5	-0.8	-0.3	-0.5	-0.2	-0.4
5000	-5.6	-6.5	-2.3	-2.9	-0.8	-1.2	-0.4	-0.7	*	-0.4
6300	-6.8	-7.9	-3	-3.7	-1	-1.5	-0.5	-0.9	-0.2	-0.5
8000	-8.2	-9.6	-3.3	-4.2	-1.6	-2	-0.7	-1.2	-0.4	-0.8
10000	-9	-10.8	-3.8	-5	-2	-2.7	-1	-1.6	-0.7	-1.2

[8] Values below 0.2 are indicated with * because they fall below the measurement uncertainty.

Freq. (Hz)	Mach Number									
	0.5		0.78		1.5		2.0		2.5	
	ΔL_1	ΔL_2	ΔL_1	ΔL_2	ΔL_1	ΔL_2	ΔL_1	ΔL_2	ΔL_1	ΔL_2
12500	-9.8	-12.1	-4.5	-6	-2	-2.8	-1.5	-2.2	-0.9	-1.5
16000	-11.6	-14.7	-5.5	-7.4	-2.5	-3.6	-1.9	-2.8	-1.4	-2.2
20000	-13.5	-17.5	-8.1	-10.5	-3.2	-4.6	-2.8	-3.9	-2.4	-3.4

Examining these data, Efimtsov concluded that the Kulite behaves as if its face diameter were about 8 mm instead of the actual 3.86 mm (see Figure 7) when applying the Corcos correction. This results in a relatively simple correction procedure for the Kulite if one can assume that it is flush mounted and that the measurements made by the B&K microphone represent the true level.

Efimtsov then investigated the transducer's behavior when it was installed not exactly flush. Deviations from flushness ranged from -100 to +100 μm (micrometers = thousandths of a millimeter). Negative flushness indicates recessed and positive indicates protruding. The results are tabulated in Table 18 – Table 22 and plotted in Figure 39 – Figure 43. From this data, corrections to the flight data for transducer flushness (see Table 4) could be applied if necessary.

Table 18: Kulite transducer non-flush frequency response - dB difference with flush (H=4.9 km, M=0.5).

Band	Freq.	Protrusion (>0) or Recession (<0) in Thousandths of a Millimeter									
No.	Hz	-100	-50	-20	-10	-5	5	10	20	50	100
14	25	4	2.8	1.3	0.5	0	0	-1	-0.5	-0.5	1.6
15	31.5	4.8	3	1.3	0.3	0	0	-1.2	-0.8	-0.3	1.6
16	40	5.5	3.2	0.9	0.3	0	0	-0.9	-1.1	0	1.6
17	50	5.2	3.4	0.9	0.3	0	0	-0.6	-1	0	1.5
18	63	4.9	3.5	0.8	0.4	0	0	-0.6	-0.9	0	1.4
19	80	4.6	3.7	0.7	0.5	0	0	-0.4	-0.8	0	1.5
20	100	4.3	3.4	0.7	0.4	0	0	-0.2	-0.7	0.2	1.5
21	125	4	2.9	0.6	0.4	0	0	-0.2	-0.6	0.3	1.5
22	160	3.9	2.9	0.6	0.2	0	0	0	-0.5	0.4	1.4
23	200	3.9	2.8	0.8	0.2	0	0	0	-0.4	0.4	1.4
24	250	3.9	2.7	1	0	0	0	0	-0.3	0.3	1.3
25	315	3.8	2.5	0.9	0	0	0	0	-0.2	0	1.3
26	400	3.5	2.3	0.9	0	0	0	0	0	0	1.2
27	500	3.4	2.2	0.8	0	0	0	0	0	0.2	1
28	630	3.2	2	0.7	0	0	0	0	0.2	0.3	0.9
29	800	2.8	1.6	0.6	0	0	0	0	0.3	0.4	0.8
30	1000	2.6	1.4	0.4	0	0	0	0	0.3	0.5	0.8
31	1250	2.2	1.3	0.4	0	0	0	0	0.2	0.4	0.7
32	1600	1.6	0.5	0.3	0	0	0	0	0	0.2	0.5
33	2000	1.3	0.5	0.2	0	0	0	0	0	0	0.3
34	2500	1.4	0.6	0	0	0	0	0	0	0	0.2
35	3150	1.6	0.6	0	0	0	0	0	0	0	0
36	4000	1.8	0.7	0.2	0	0	0	0	0	0	0
37	5000	2	0.8	0.3	0	0	0	0	-0.2	-0.2	-0.3
38	6300	2.1	0.8	0.4	0	0	0	0	-0.2	-0.3	-0.4
39	8000	2.3	1	0.4	0	0	0	-0.2	-0.3	-0.4	-0.5
40	10000	2.4	1.1	0.5	0.2	0	0	-0.2	-0.3	-0.4	-0.5
41	12500	2.2	0.9	0.5	0.2	0	0	0	-0.2	-0.3	-0.4
42	16000	2.7	1	0.4	0.2	0	0	0	0	0	0
43	20000	3.6	1.1	0.2	0	0	0	0	0	0.4	0.5

Table 19: Kulite transducer non-flush frequency response - dB difference with flush (H=4.9 km, M=0.78).

Band	Freq.	Protrusion (>0) or Recession (<0) in Thousandths of a Millimeter									
No.	Hz	-100	-50	-20	-10	-5	5	10	20	50	100
14	25	4.7	5.2	1.3	0.3	0	0	-0.4	-1.2	1.3	3.8
15	32	4.9	5.4	1.4	0.5	0	0	-0.6	-0.9	1.2	3.7
16	40	5.3	5.5	1.6	0.7	0	0	-0.9	-0.4	1.1	3.9
17	50	5.2	5.3	1.6	1	0	0	-0.7	-0.2	1	3.7
18	63	5.1	4.9	1.7	1.2	0	0	-0.4	0	0.9	3.6
19	80	5	4.8	1.8	0.8	0	0	-0.2	-0.2	0.8	3.5
20	100	4.9	4.5	1.8	0.6	0	0	0	-0.3	0.8	3.3
21	125	4.8	4.1	1.8	0.5	0	0	-0.3	-0.4	0.8	3.2
22	160	4.4	3.9	1.6	0.3	0	0	-0.6	-0.6	0.7	3
23	200	4.3	4	1.5	0.3	0	0	-0.6	-0.5	0.7	2.8
24	250	4.2	3.9	1.4	0.5	0	0	-0.7	-0.5	0.8	2.6
25	315	4.2	3.9	1.4	0.5	0	0	-0.5	-0.4	0.7	2.6
26	400	4.2	3.9	1.3	0.6	0	0	-0.4	-0.3	0.8	2.5
27	500	4.1	3.9	1.3	0.7	0	0	-0.3	-0.4	0.6	2.4
28	630	4.1	3.8	1.4	0.7	0	0	-0.2	-0.4	0.5	2.3
29	800	4	3.8	1.4	0.7	0	0	0	-0.6	0.5	2.2
30	1000	3.8	3.3	1.2	0.5	0	0	0	-0.4	0.4	1.9
31	1250	3.6	3	1	0.3	0	0	0	-0.3	0.3	1.6
32	1600	3.1	2.5	0.8	0.4	0	0	0	-0.2	0.3	1.3
33	2000	2.9	2.3	0.7	0.3	0	0	0	0	0.2	0.9
34	2500	2.8	2	0.6	0.2	0	0	0	0	0.2	1
35	3150	2.9	1.9	0.6	0.2	0	0	0	0	0	0.8
36	4000	2.8	1.6	0.5	0.2	0	0	0	0	0	0.4
37	5000	2.6	1.3	0.3	0	0	0	0	0	0	0
38	6300	2.5	1.2	0.4	0.2	0	0	0	0	-0.2	-0.2
39	8000	2.3	1.2	0.3	0.2	0	0	0	-0.2	-0.3	-0.5
40	10000	2.4	1.2	0.4	0	0	0	0	-0.2	-0.3	-0.6
41	12500	2.5	1.2	0.3	0.2	0	0	0	-0.2	-0.4	-0.8
42	16000	2.7	1.3	0.4	0.2	0	0	-0.2	-0.2	-0.5	-1
43	20000	3.1	1.4	0.5	0.3	0	0	-0.3	-0.3	-0.6	-1.1

Table 20: Kulite transducer non-flush frequency response - dB difference with flush (H=13.8 km, M=1.5).

Band No.	Freq. Hz	Protrusion (>0) or Recession (<0) in Thousandths of a Millimeter									
		-100	-50	-20	-10	-5	5	10	20	50	100
14	25	3.6	2.3	-0.9	0.8	0	2.3	2.7	4.6	6.9	10.8
15	31.5	3.3	1.9	-2.4	0.9	0	1.7	2	3	6.4	9.7
16	40	1.8	1.6	-1.7	0.5	0	0.3	1.6	3.1	6.3	9.5
17	50	1.6	1.3	-1.2	-0.5	0	0.5	1.4	3.1	5.6	9
18	63	2.2	0.9	-1.3	-0.7	0	0.7	1.4	3.2	5.5	8.8
19	80	2.4	0.6	-1.1	-0.4	0	0.9	1.7	2.8	5.4	8.7
20	100	2.3	0.8	-1	-0.2	0	0.8	1.7	2.5	5.5	8.3
21	125	2	1.1	-0.8	0	0	0.7	1.6	2.3	5.5	7.9
22	160	1.5	0.9	-0.5	0	0	0.7	1.4	2.1	5.1	7.8
23	200	1.2	0.8	-0.2	0	0	0.7	1.3	2.2	5	7.7
24	250	1.3	0.9	0	0	0	0.8	1.3	2.1	5	7.6
25	315	1.1	0.7	-0.3	0	0	0.8	1.2	2	4.7	7.5
26	400	0.9	0.6	-0.5	0	0	0.6	1.1	1.9	4.4	7.3
27	500	0.5	0.4	-0.6	0	0	0.5	1	1.7	4.1	7
28	630	0.6	0.3	-0.6	0	0	0.5	0.9	1.7	3.9	6.7
29	800	0.4	0.2	-0.5	0	0	0.4	0.8	1.6	4.1	6.8
30	1000	0.2	0	-0.5	0	0	0.4	0.8	1.6	4	6.6
31	1250	0	0	-0.4	0	0	0.5	0.8	1.5	3.9	6.5
32	1600	-0.2	-0.3	-0.4	0	0	0.4	0.7	1.3	3.7	6.2
33	2000	-0.3	-0.3	-0.3	0	0	0.3	0.6	1.2	3.1	5.5
34	2500	-0.5	-0.5	-0.3	0	0	0.2	0.5	1	2.6	4.9
35	3150	-0.6	-0.4	-0.2	0	0	0.2	0.5	0.9	2.2	4.2
36	4000	-0.6	-0.3	-0.2	0	0	0	0.4	0.7	1.8	3.5
37	5000	-0.6	-0.2	0	0	0	0	0.3	0.5	1.3	2.7
38	6300	-0.7	-0.2	0	0	0	0	0	0.2	0.7	1.9
39	8000	-0.9	-0.2	0	0	0	0	-0.2	0	0	0.6
40	10000	-0.9	0	0	0	0	0	-0.2	-0.2	-0.5	-0.4
41	12500	-0.7	0	0	0	0	0	-0.3	-0.3	-0.9	-1.1
42	16000	-0.2	0.4	0.3	0	0	0	-0.3	-0.4	-1.1	-1.7
43	20000	0.4	0.7	0.4	0.2	0	-0.2	-0.4	-0.5	-1.4	-2.1

Table 21: Kulite transducer non-flush frequency response - dB difference with flush (H=16.8 km, M=2.0).

Band	Freq.	Protrusion (>0) or Recession (<0) in Thousandths of a Millimeter									
No.	Hz	-100	-50	-20	-10	-5	5	10	20	50	100
14	25	2.7	-3.2	-2.5	-1.1	0	0.5	-1	1.4	0.9	3.5
15	31.5	3.5	-2.5	-1.7	-1	0	0.2	-0.7	1.5	1.4	3.3
16	40	4.5	-1.9	-1.3	-0.8	0	-0.4	-0.2	1.7	1.9	3.1
17	50	4.2	-1.5	-1.1	-0.9	0	-0.5	0	1.6	2	3.1
18	63	4.1	-1.3	-0.9	-0.8	0	-0.8	0	1.5	1.9	3.1
19	80	4.1	-1.3	-1.1	-0.6	0	-0.5	0.3	1.4	1.8	3.1
20	100	4	-1.1	-0.9	-0.4	0	-0.3	0.2	1.3	1.5	2.9
21	125	4	-0.9	-0.7	-0.3	0	-0.2	0.2	1.2	1.4	2.8
22	160	3.7	-0.6	-0.5	-0.2	0	0	0	1.2	1.3	2.7
23	200	3.3	-0.5	-0.3	-0.2	0	0	0	1.1	1.2	2.9
24	250	3.1	-0.4	-0.2	0	0	0.2	0	1.1	1.2	2.9
25	315	2.7	-0.3	0	0	0	0	0	1.1	1.2	3
26	400	2.6	-0.2	0	0	0	0.2	0	1	1.2	2.8
27	500	2.3	0	0	0	0	0.3	0	1	1.1	2.7
28	630	2.2	0	0	0	0	0.2	0	0.8	1	2.6
29	800	1.6	-0.2	0	0	0	0.2	0.2	0.8	0.9	2.5
30	1000	1.5	-0.2	0	0	0	0	0.2	1	0.9	2.4
31	1250	1.4	0	0.2	0	0	0	0.2	1	0.8	2.2
32	1600	1.2	0	0.2	0	0	0	0.3	0.9	0.8	2.1
33	2000	1	0	0.3	0.2	0	0	0.2	0.8	0.7	1.8
34	2500	0.8	0	0.3	0.2	0	0	0	0.8	0.6	1.7
35	3150	1	0	0.2	0	0	0	0	0.8	0.5	1.4
36	4000	0.7	0	0	0	0	0	0	0.7	0.5	1.1
37	5000	0.7	0	0	0	0	0	0	0.5	0.2	0.7
38	6300	0.7	0.2	0.2	0	0	0	0	0.3	0	0.4
39	8000	0.8	0.3	0.3	0.2	0	0	0	0.2	-0.2	0
40	10000	0.9	0.4	0.4	0.2	0	0	0	0	-0.5	-0.6
41	12500	1	0.6	0.5	0.2	0	0	0	0	-0.6	-1.1
42	16000	1.6	1	0.6	0.3	0	0	0	-0.4	-0.9	-1.7
43	20000	2.4	1.3	0.6	0.3	0	0	-0.2	-0.5	-1	-2

Table 22: Kulite transducer non-flush frequency response - dB difference with flush (H=16.8 km, M=2.5).

Band	Freq.	Protrusion (>0) or Recession (<0) in Thousandths of a Millimeter									
No.	Hz	-100	-50	-20	-10	-5	5	10	20	50	100
14	25	3	1.5	-0.9	0.5	0.3	-1.3	-1	-1.2	-0.8	2.3
15	31.5	3.1	1.7	-0.7	0.7	0.2	-1.2	-1.7	-1.4	-1.4	1.2
16	40	3.2	2.4	-0.5	1.1	0	-0.9	-2.5	-1.6	-2.2	0.3
17	50	3.5	2	-0.2	0.8	0	-0.7	-1.5	-1.4	-1	0
18	63	3.9	1.8	0	0.5	0	-0.4	-1.1	-1.3	-0.9	0
19	80	3.7	1.6	0	0.3	0	-0.5	-1	-1	0	0.7
20	100	3.5	1.6	0.5	0.4	0	-0.5	-0.9	-0.9	-0.3	0.5
21	125	3.2	1.8	0.6	0.4	0	-0.5	-0.9	-0.8	-0.5	0.4
22	160	2.8	1.5	0.6	0.3	0	-0.6	-0.8	-0.5	-0.6	0.7
23	200	2.6	1.5	0.5	0.2	0	-0.6	-0.8	-0.4	-0.5	0.8
24	250	2.4	1.4	0.4	0	0	-0.4	-0.7	-0.4	-0.2	1
25	315	2.3	1.3	0.3	0	0	-0.4	-0.6	-0.5	0	0.9
26	400	2.2	1	0.2	0	0	-0.4	-0.5	-0.6	0	1
27	500	1.8	0.8	0	0	0	-0.3	-0.4	-0.5	0	1
28	630	1.5	0.6	0	0	0	-0.2	-0.4	-0.4	0	1.1
29	800	1.4	0.5	0	0	0	-0.2	-0.4	-0.3	0	1
30	1000	1.3	0.4	0	0	0	-0.2	-0.3	-0.4	0	1
31	1250	1	0.3	0	0	0	-0.2	-0.3	-0.4	0	0.9
32	1600	0.8	0.2	0	0	0	0	-0.3	-0.4	0	0.9
33	2000	0.7	0.2	0	0	0	0	-0.3	-0.3	0	0.9
34	2500	0.6	0	0	0	0	0	0	-0.2	0	1
35	3150	0.5	0	0	0	0	0	0	-0.2	0	1
36	4000	0.4	0	0	0	0	0	-0.2	-0.3	0	0.9
37	5000	0.3	0	0	0	0	0	-0.2	-0.3	0	0.8
38	6300	0	0	0	0	0	0	0	-0.3	0	0.5
39	8000	0.2	0.3	0	0	0	0	-0.3	-0.4	-0.3	0.2
40	10000	0.2	0.5	0.2	0	0	0	0	-0.5	-0.4	0
41	12500	0.4	0.7	0.3	0	0	0	-0.3	-0.6	-0.7	-0.7
42	16000	0.7	1	0.3	0.2	0	0	-0.5	-0.8	-0.9	-1.1
43	20000	1.3	1.3	0.4	0.3	0.2	-0.2	-0.6	-0.9	-1.2	-1.8

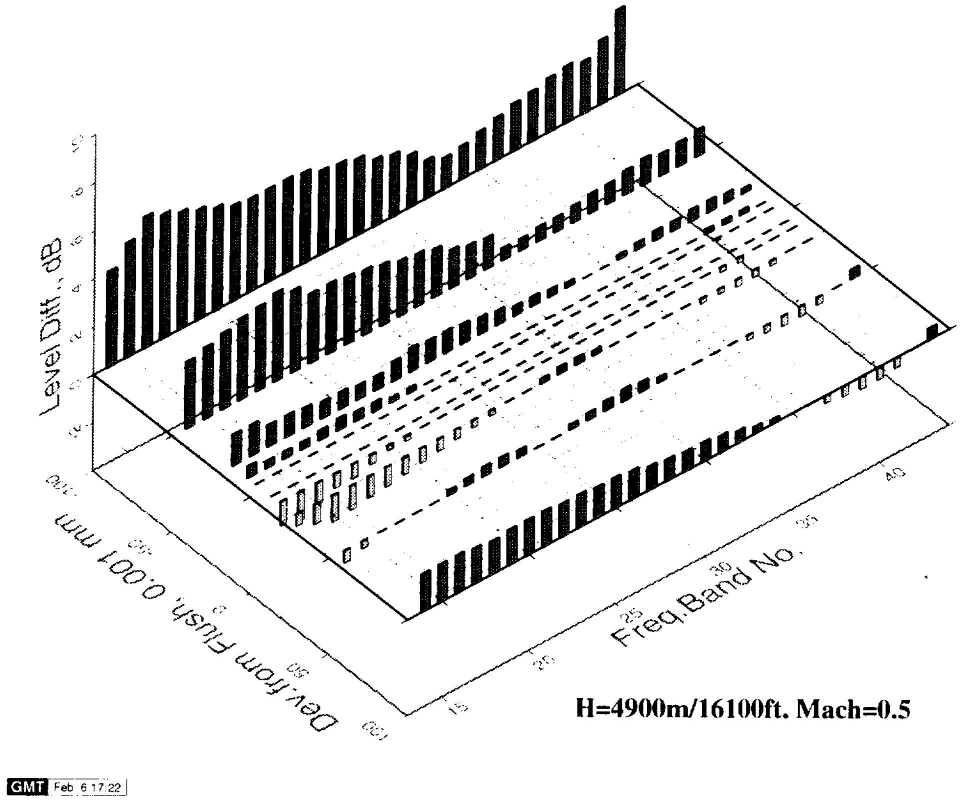


Figure 39: Kulite transducer non-flush frequency response (H=4.9 km, M=0.5).

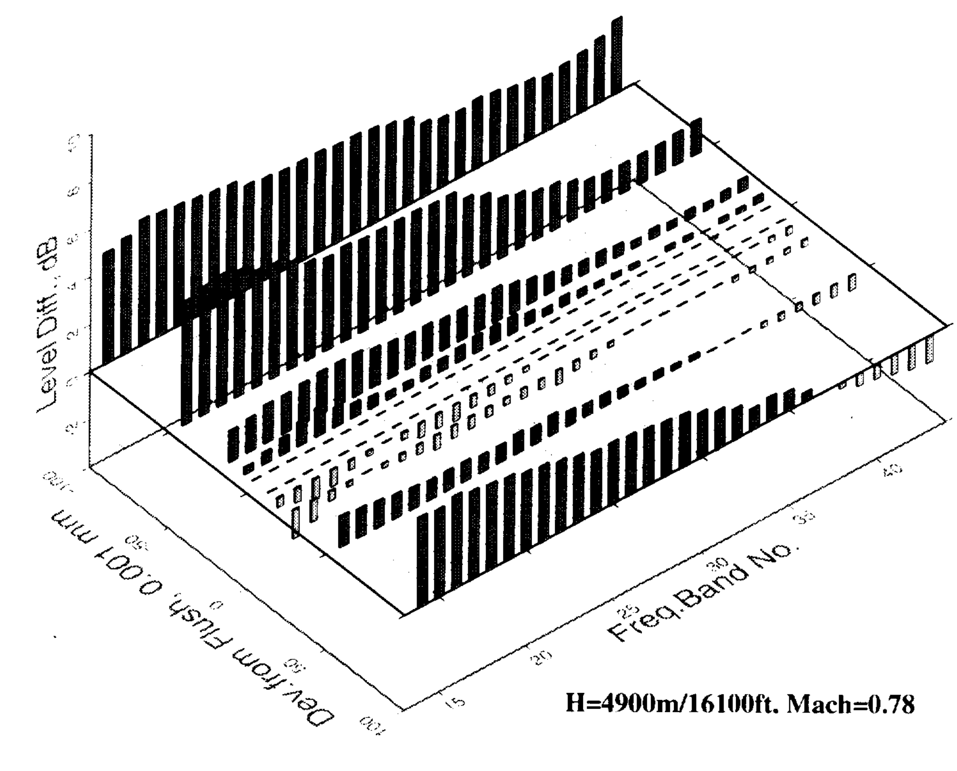


Figure 40: Kulite transducer non-flush frequency response (H=4.9 km, M=0.78).

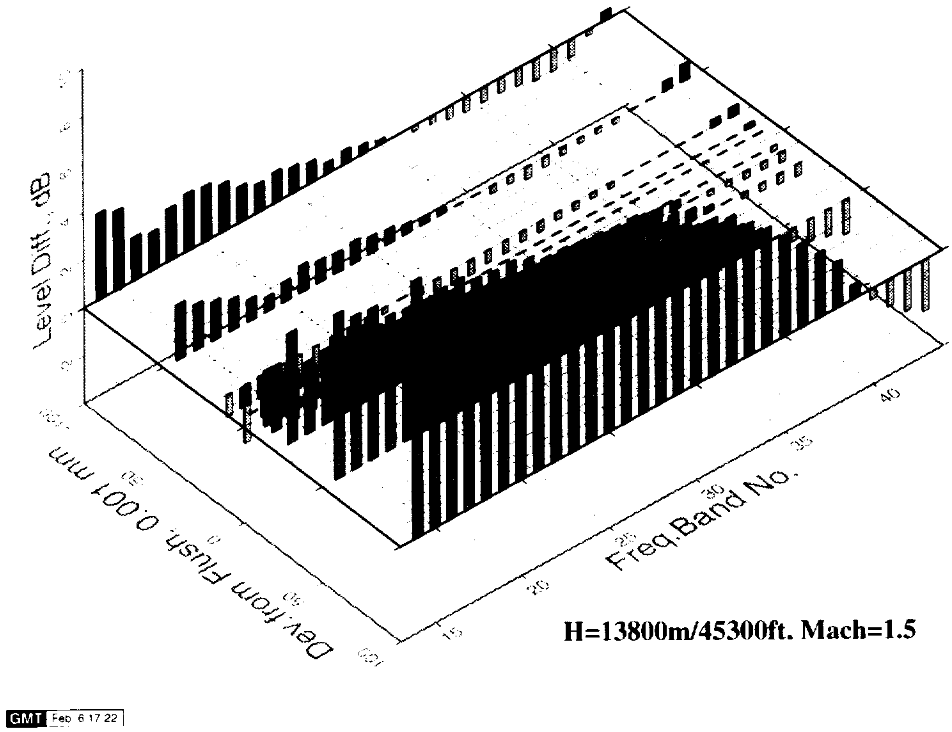


Figure 41: Kulite transducer non-flush frequency response (H=13.8 km, M=1.5).

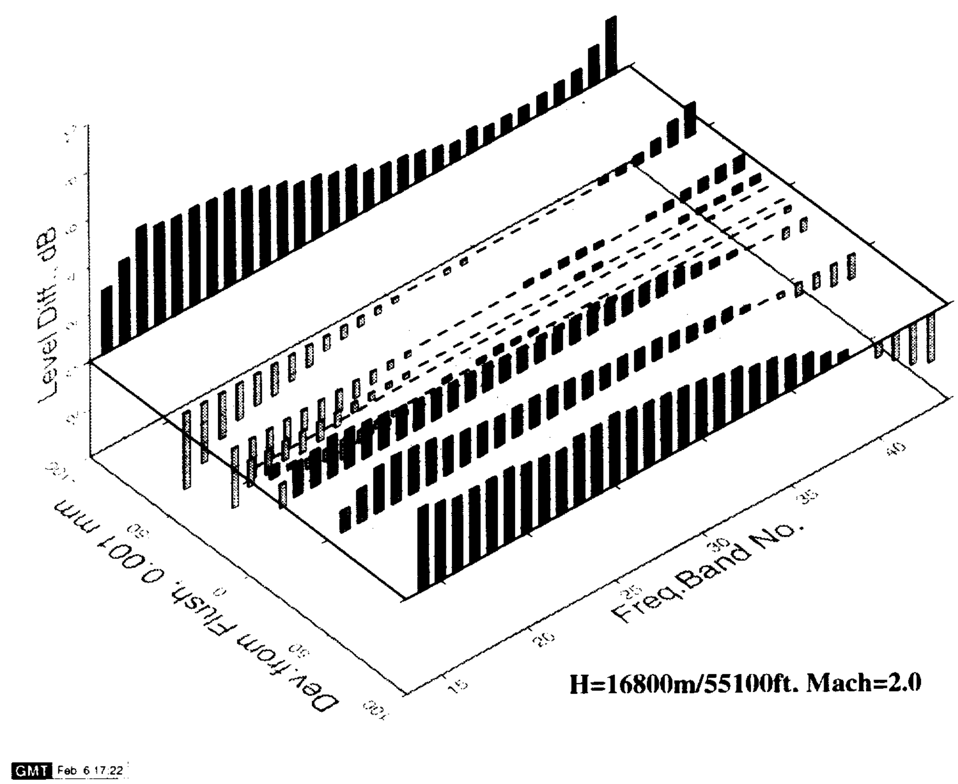


Figure 42: Kulite transducer non-flush frequency response (H=16.8 km, M=2.0).

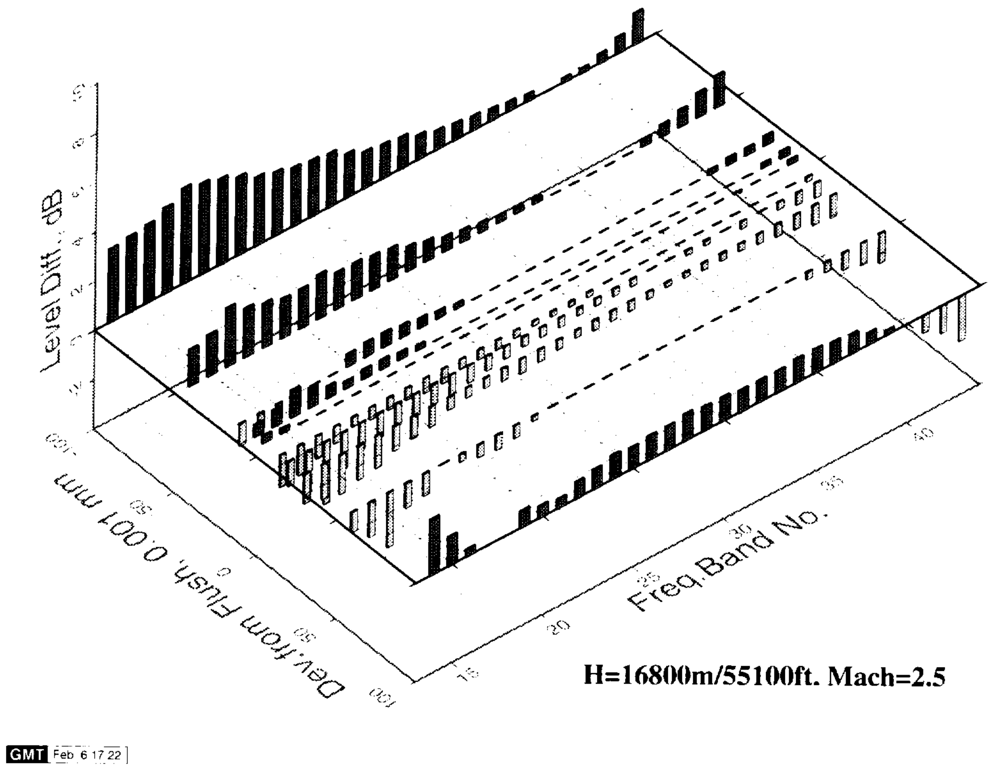


Figure 43: Kulite transducer non-flush frequency response (H=16.8 km, M=2.5).

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8. Acknowledgements

The authors wish to recognize the following individuals for their contributions to Experiment 2.1.

NASA Langley Research Center

Research & Technology Group

Structural Acoustics Branch; FMAD

- Lori M. Jones (Travel orders & support)
- Brenda M. Sullivan (Operator procedures development)

Internal Operations Group

Flight Instrumentation Branch; AESD

- Fred Fitzpatrick (Kulite signal conditioning operational testing)
- Donna A. Gallaher (Coordinated shipment to Russia and supported flight test)
- F. Keith Harris (Instrumentation pallet electrical design and supported flight test)
- Kelly Johnson (Travel orders & support)
- Vernie Knight, Jr. (Instrumentation engineer and supported flight test)

Engineering Design Branch; AMSD

- Keith W. Davis (Instrumentation pallet mechanical design)

Aeroacoustics & Hypersonic Propulsion Support Section; Gas, Fluid & Acoustics Research Support Branch; FSSD

- Robert A. Baals (Kulite calibration alignment fixture)
- H. Stanley Hogge (Data reduction)

Space and Facility Support Section; Metals Applications Technology Branch; FD

- Warren (Sandy) S. Hartraft (Hardware and pallet fabrication)
- Paul G. Link (Hardware and pallet fabrication)
- Rolando Padilla (Hardware and pallet fabrication)
- Ronald T. Topping (Hardware and pallet fabrication)

Numerical Control Section; Metals Applications Technology Branch; FD

- David T. Fahringer (Kulite insulating boss fabrication)

Electronic Instrumentation Development Section; Electronics Technology Branch; FD

- Wayne A. Davis (Provided electrical and electronic fabrication support)
- Noel Hudgins (Provided electrical and electronic fabrication support)
- Mark W. Wynkoop (Provided electrical and electronic fabrication support)

Quality Assurance Office; FOSD

- Michael A. Klebitz (Inspected equipment for flight worthiness)

US Army

US Army Retired

- Tim D. Bryant (Mechanical design for Kulite signal conditioning)

Support Service Contractors

Raytheon (Electrical and electronic fabrication, Flight hardening equipment)

- Jeri Carter
- Charles (Tom) T. Feigh
- Carol Hayes
- Delores Russell
- Paul Timbrell

NEMA

- Jennifer Allen (Environmental and operational testing)
- Sheryl Johnson (Drawing and documentation support, Instrumentation test procedure development)
- Ralph Kimbrell (Environmental testing)
- Doug Taylor (Kulite signal conditioning/multiplexer switch)

The Boeing Company

- Dennis Pierce, Candis Kuhlman, and Mark Battles (subcontract administration, purchasing, shipping)
- Annette Anderson (office administration, travel)
- Kerry Johnsen (business administration)
- Diane Tatterson (librarian for documents and drawings)
- Waman Bhat (home office backup)

The McDonnell Douglas Company

- Myles Simpson, Gopal Mathur, Ted Beier (test planning)

ANTK Tupolev

- Professor Alexander Poukhov (Tu-144 Chief Constructor)
- Vyacheslav Sablev (Tu-144 Instrumentation Chief)
- Igor Ginko (Lead - Sonic fatigue loads experiment)
- Rafael Minayev (Sonic fatigue loads experiment)
- Mikhail Kalmanovich (Tu-144 Structure Chief)
- Edgar Krupyanksi (Flight Chief)
- Andre Krupyanksi (Experiment 2.1 equipment operator)
- Boris Mirimov (Management and logistics support)
- Alexander Sudakov (Instrumentation Lead)
- Sergei Burmistrov (Instrumentation engineer)

IBP Aircraft Ltd.

- Mikhail Melnichenko, Sergei Karabanov, Vladimir Merinov, Yuri Tsibulin (liaison and translation services)

Appendix A Aircraft Drawings

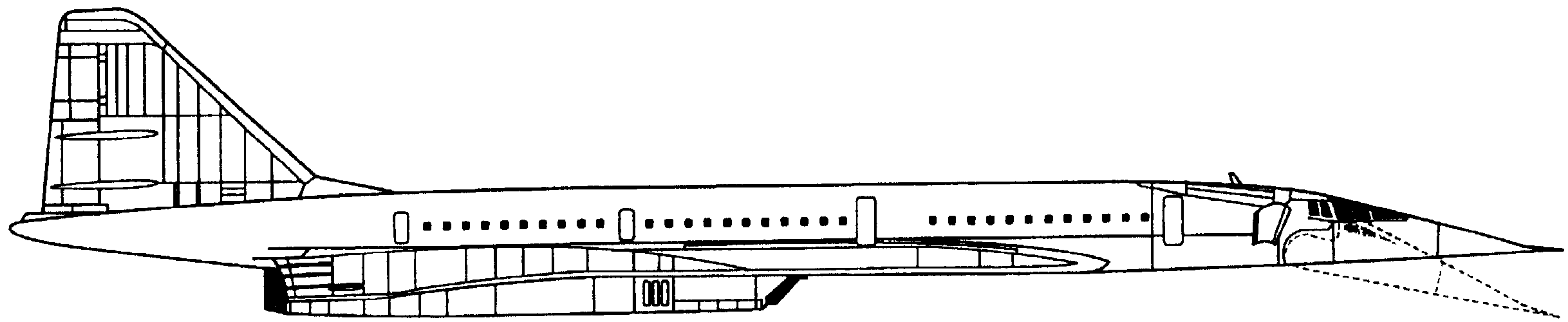


Figure 44: Tu-144 elevation drawing.

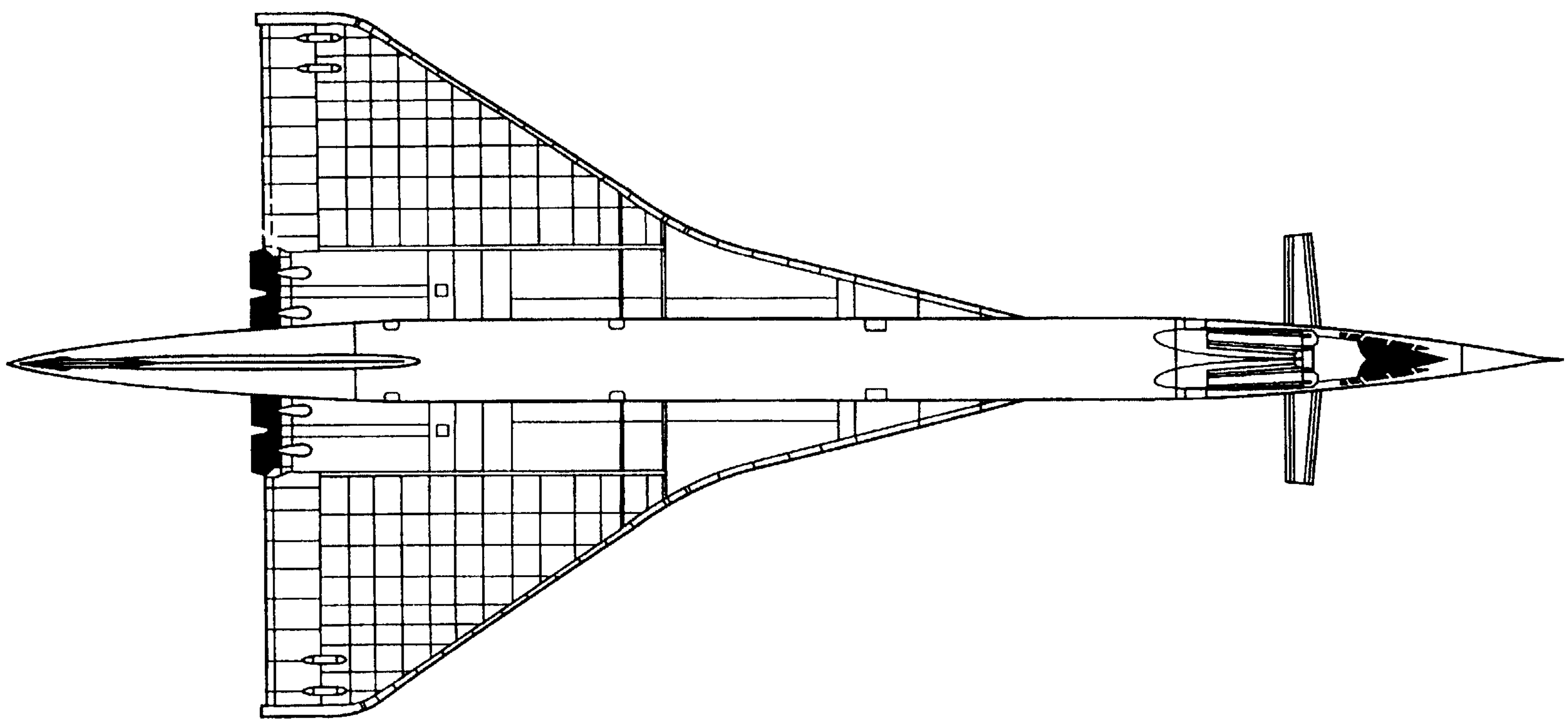


Figure 45: Tu-144 planform drawing.

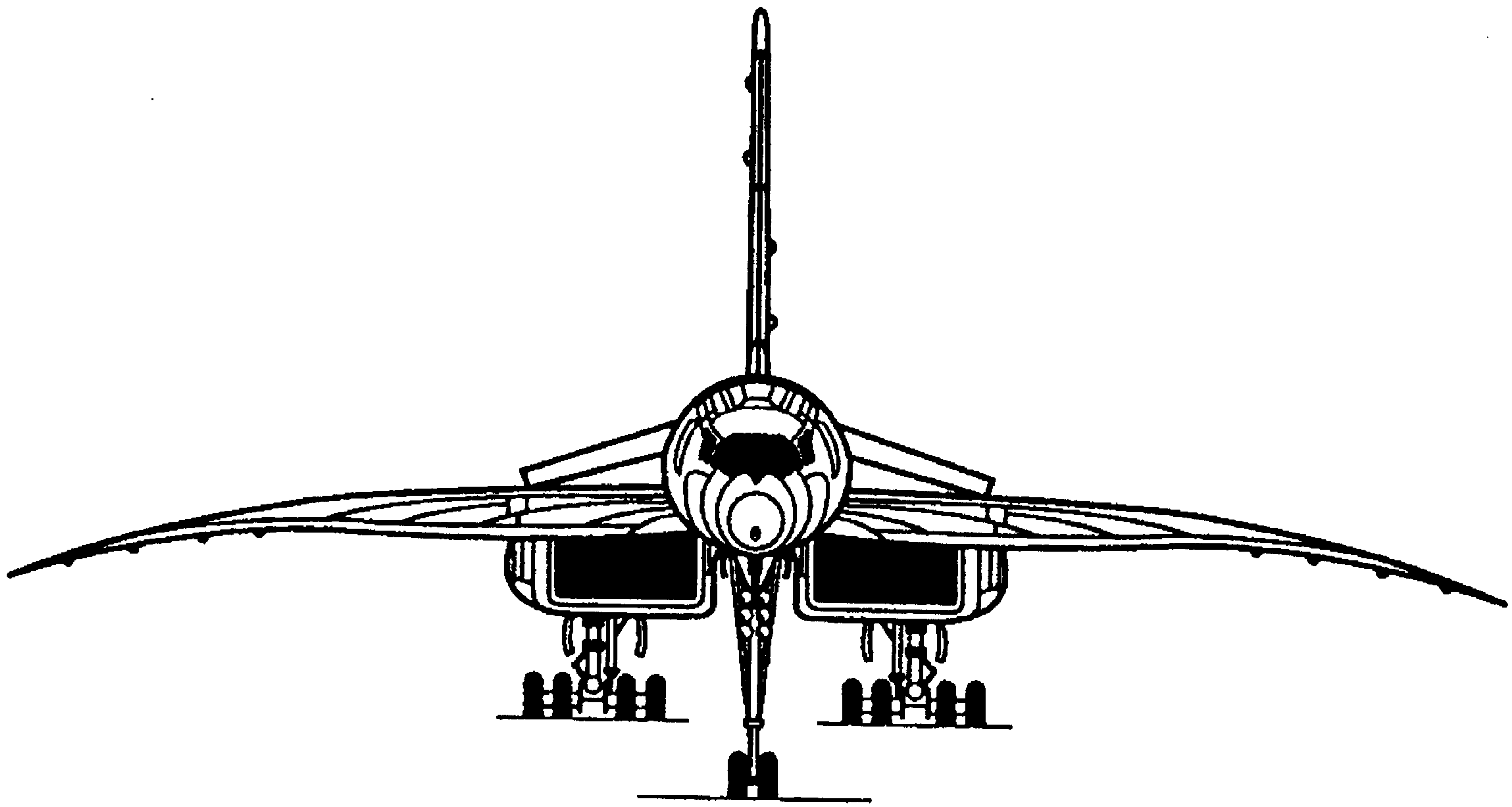


Figure 46: Tu-144 front-view drawing.

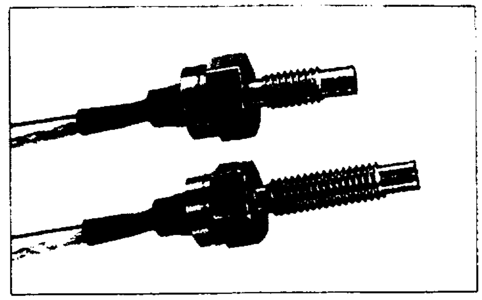
Appendix B Transducer Specification Sheets

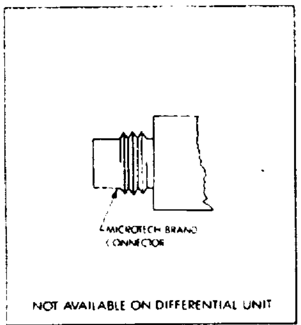
HIGH SENSITIVITY

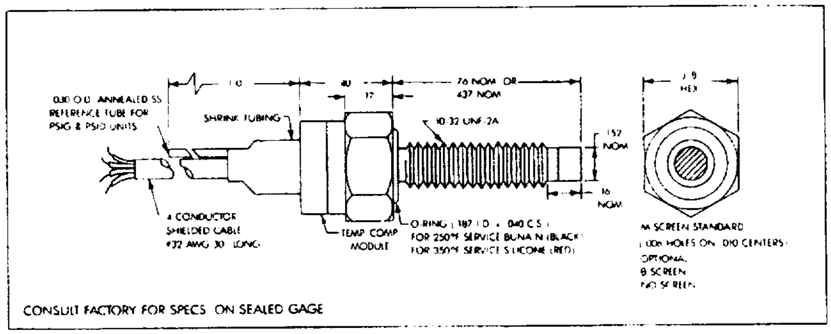
HIGH SENSITIVITY IS PRESSURE TRANSDUCERS

XCS-190 SERIES HIGH IMPEDANCE
XCW-190 SERIES LOW IMPEDANCE

- **High Output**
- **High Natural Frequency**







	XCS		XCW	
INPUT				
Pressure Range	5	15 PSI	5	15 PSI
Operational Mode	Absolute, Gage, Sealed Gage, Differential			
Over Pressure	15	45 PSI	15	45 PSI
Burst Pressure	5 Times Rated Pressure			
Pressure Media	All Nonconductive, Noncorrosive Liquids or Gases			
Rated Electrical Excitation	15 VDC/AC			
Maximum Electrical Excitation	20 VDC/AC			
Input Impedance	1200 Ohms (Min.)	1200 Ohms (Min.)	800 Ohms (Min.)	800 Ohms (Min.)
OUTPUT				
Output Impedance	1000 Ohms (Nom.)	1000 Ohms (Nom.)	1000 Ohms (Nom.)	1000 Ohm (Nom.)
Full Scale Output (FSO)	150 mV (Nom.)	200 mV (Nom.)	100 mV (Nom.)	200 mV (Nom.)
Residual Unbalance	±5% FSO			
Combined Non-Linearity And Hysteresis	±0.3% FS BFSL (Max.)			
Hysteresis	0.1% (Typ.)			
Repeatability	0.1% (Typ.)			
Resolution	Infinite			
Natural Frequency (KHz)	100	150	100	150
Acceleration Sensitivity % FS/g Perpendicular Transverse	.005 .0005	.002 .0002	.005 .0005	.002 .0002
Insulation Resistance	100 Megohm Min. at 50 VDC			
ENVIRONMENTAL				
Operating Temperature Range	-65F to 250°F (-55°C to 120°) Temperatures to 350°F (175°C) Available on Special Order			
Compensated Temperature Range	80°F to 180°F (25°C to 80°C) Any 100°F Range Within The Operating Range on Request			
Thermal Zero Shift	±2% FS/100°F (Typ.)			
Thermal Sensitivity Shift	±2%/100°F (Typ.)			
Steady Acceleration	10,000g. (Max.)			
Linear Vibration	0-2,000 Hz Sine, 100g. Max.			
PHYSICAL				
Electrical Connection	4 Conductor 32 AWG Shielded Cable 24" Long			
Weight	5 Grams (Nom.) Excluding Module and Leads			
Sensing Principle	Fully Active Four Arm Wheatstone Bridge Diffused Into Silicon Diaphragm			
Mounting Torque	15 Inch-Pounds (Max.)			

These units are available with metric size threads. Std. Metric Thread M5 x .8 XT-67M-190 On special order M5 x .5 XT1M-190

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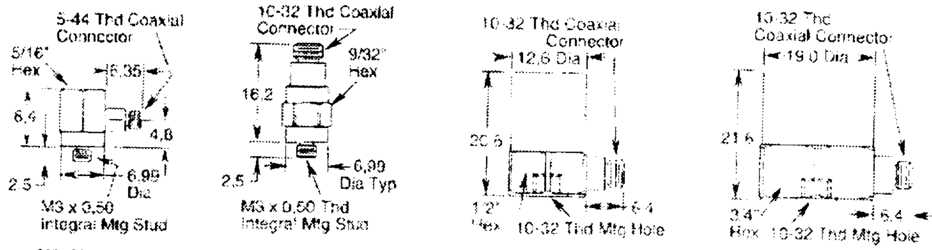
Figure 47: Kulite transducer XCS-190-15D specification sheet.

32 HIGH TEMPERATURE ~ QUARTZ SHEAR ICP® with built-in electronics

SI (metric) Selection Guide

SENSORS WITH 10-32 MOUNTING HOLE SUPPLIED WITH 10-32 TO M6 X 0.75 ADAPTOR STUD
Dimensions shown in millimeters except where noted



M359B15 (M359B16) | M359B18 | M359B01 & B03 (M359B02 & B04) | M359B33 (M359B34)

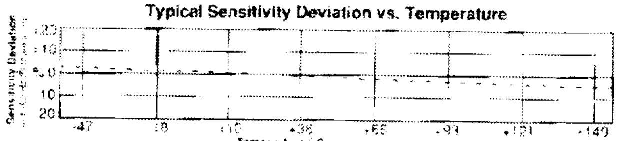
Top connector model numbers used in parentheses. (Dimensional drawings not shown.)

MODEL NUMBER	Unit	HIGH FREQUENCY / LOW MASS M359B15	HIGH FREQUENCY / LOW MASS M359B18	GENERAL PURPOSE M359B03	GENERAL PURPOSE M359B01	HIGH SENSITIVITY M359B33
Voltage Sensitivity (1)	mV/m/s²	1,02	1,02	1,02	2,04	10,2
Frequency Range (±5%) (2)	Hz	2 to 10 000	2 to 10 000	2 to 7 000	2 to 7 000	2 to 4 000
(±10%)	Hz	1,5 to 18 000	1,5 to 15 000	1,5 to 11 000	1,5 to 10 000	1,5 to 7 000
Resonant Frequency	kHz	≥ 70	≥ 50	≥ 38	≥ 38	≥ 22
Amplitude Range	±m/s² pk	3 924	3 924	3 924	1 962	392
Resolution (broadband)	m/s² pk	0,1	0,1	0,1	0,05	0,01
Mechanical Shock Limits	±m/s² pk	98 100	98 100	98 100	98 100	19 620
Temperature Range	°C	-54 to +163	-54 to +163	-54 to +163	-54 to +163	-54 to +163
Temperature Coefficient (3)	%/°C	see graph	see graph	see graph	see graph	see graph
Amplitude Linearity	%	± 1	± 1	± 1	± 1	± 1
Transverse Sensitivity	%	≤ 5	≤ 5	≤ 5	≤ 5	≤ 5
Base Strain Sensitivity	m/s²/µε	≤ 0,02	≤ 0,02	≤ 0,005	≤ 0,005	≤ 0,002
Excitation Voltage	VDC	18 to 30	18 to 30	18 to 30	18 to 30	18 to 30
Constant Current Excitation (4)	mA	2 to 8	2 to 8	2 to 8	2 to 8	2 to 8
Output Impedance	ohm	≤ 300	≤ 300	≤ 300	≤ 300	≤ 300
Output Bias Voltage	VDC	7 to 12	7 to 12	7 to 12	7 to 12	7 to 12
Discharge Time Constant	second	≥ 0,25	≥ 0,25	≥ 0,25	≥ 0,25	≥ 0,25
Sensing Element	quartz	tri-shear	tri-shear	tri-shear	tri-shear	tri-shear
Connector	type	5-44 coax	10-32 coax	10-32 coax	10-32 coax	10-32 coax
Sealing	type	weld/herm	weld/herm	weld/herm	weld/herm	weld/herm
Mounting Thread	size	M3 x 0,50	M3 x 0,50	10-32	10-32	10-32
Housing	material	titanium	titanium	titanium	titanium	titanium
Weight	gram	2	1,8	10	10	25
OPTIONAL MODELS: (5)						
Top Connector		M359B16	standard	M359B04	M359B02	M359B34
Ground Isolated (>10⁸ ohms)		JM359B15	JM359B18	JM359B03	JM359B01	JM359B33
Adhesive Mount		A359B15	A359B18	AM359B03	AM359B01	AM359B33
Waterproof Connection		WM359B15	WM359B18	WM359B03	WM359B01	WM359B33
SUPPLIED ACCESSORIES: (6, 7)						
Mounting Stud (8)		N/A	N/A	M081B05	M081B05	M081B05
OPTIONAL ACCESSORIES: (6)						
Adhesive Mounting Base		M080A15	M080A15	M080A	M080A	M080A12
Magnetic Mounting Base		M080A30	M080A30	080A27	080A27	080A27
Triaxial Mounting Adaptor		M080A16	M080A16	M080B10	M080B10	080A11
CABLING: (6)						
Mating Cable Connectors	type	F, G	A, H, K, W	A, H, K, W	A, H, K, W	A, H, K, W
Recommended Stock Cable	series	002	002	002	002	002

NOTES:

1. General purpose & high sensitivity models have a sensitivity tolerance of ±5%. High frequency, low mass have ±10% tolerance.
2. Low end frequency range below 250 °F (121 °C) is 1 Hz (±5%) and 0,7 Hz (±10%).
3. Within 5% of typical graph.
4. Supplying constant current excitation greater than 8 mA may destroy built-in electronics.
5. See page 8 for a description of the optional models. (Specifications may differ slightly. Consult factory before ordering.)
6. See cables/accessories section beginning on page 78 for a complete description of the supplied and optional accessories.

Typical Sensitivity Deviation vs. Temperature



7. NIST traceable calibration certificate from 10 Hz to +5% frequency point supplied with each accelerometer.
8. Supplied mounting stud is threaded 10-32 to M6 x 0.75.

Figure 48: Accelerometer specification sheet.

Appendix C Electrical Drawings

POWER CONTROL

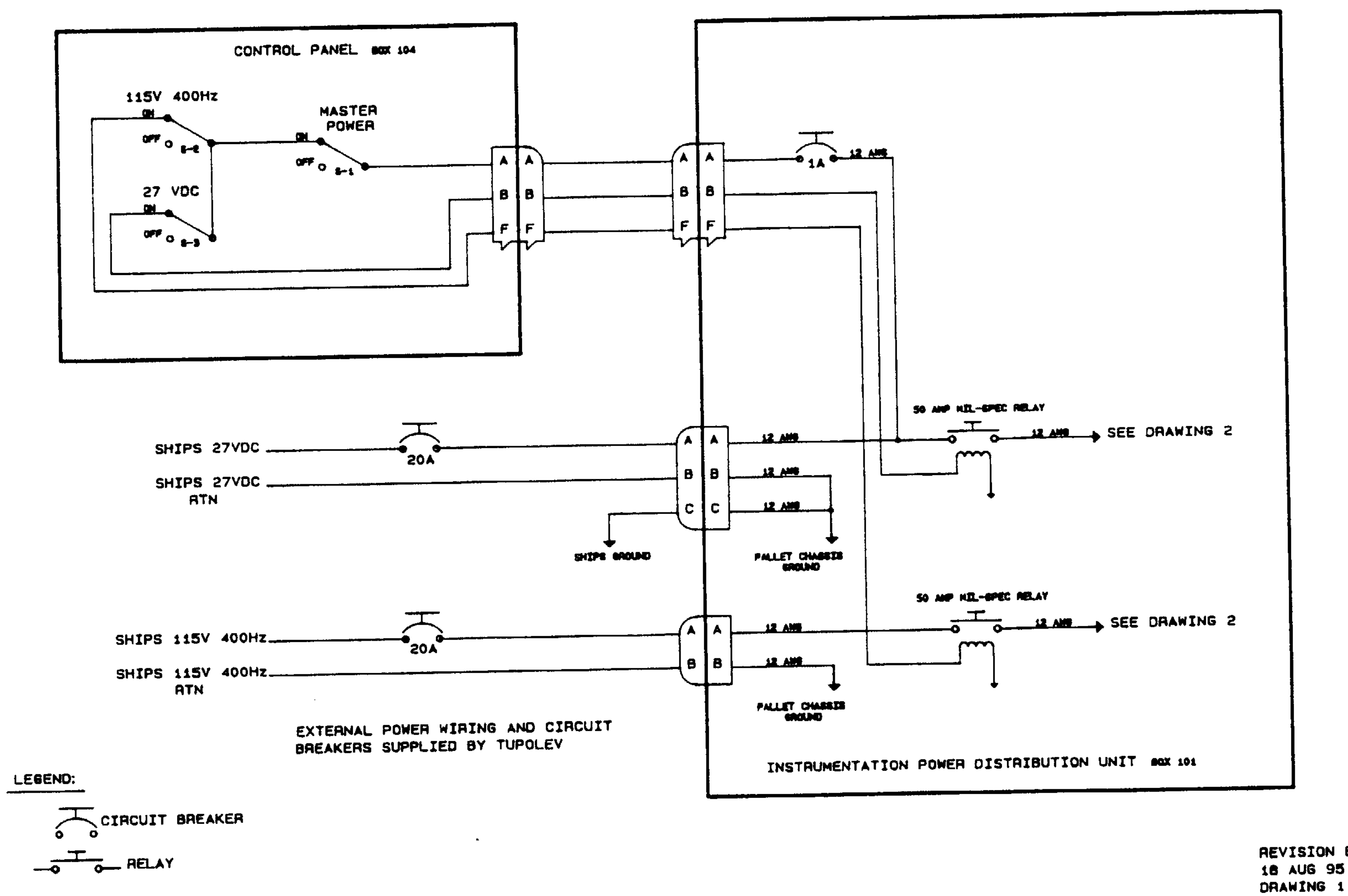


Figure 49: Wiring schematic for the power control system.

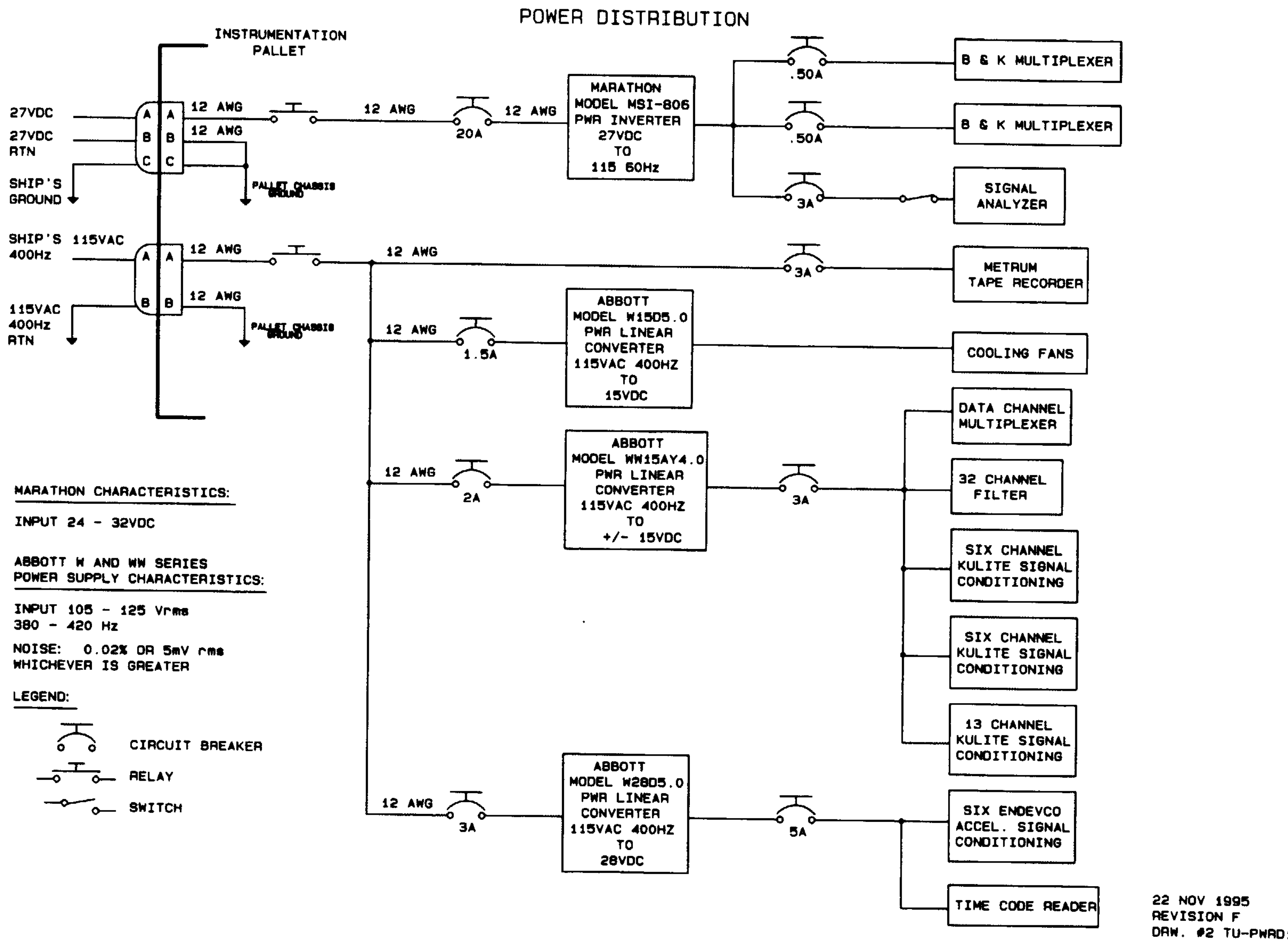


Figure 50: Wiring schematic for the power distribution system.

Appendix D Ground Runup Procedures

Последовательность гонок двугателей с целью измерения шумов в кабине и звуковой нагрузки на обшивку фюзеляжа	Срок Duration	Режим Conditi on	Sequence of Engine Ground Run-ups for Measuring Cabin Noise and Sonic Load on Fuselage Skin
1. Поочередно запустить двигатели 1,2,3,4 вместе с их генераторами	≈10 min		1. Start engines 1, 2, 3, and 4 in order, together with their generators
2. Включить систему кондиционирования воздуха			2. Turn on air conditioning system
3. Прогнать все двигатели в режиме малого газа (Для эксперимента 2.1 данные записываются на стороне А, а затем на стороне В)	5 min	G1	3. Operate all engines in idle state (Experiment 2.1 takes data on bank A, and then on bank B)
4. Выключить систему кондиционирования воздуха			4. Turn off air conditioning system
5. Прогнать все двигатели в режиме малого газа (Для эксперимента 2.1 данные записываются на стороне А, а затем на стороне В)	5 min	G2	5. Operate all engines in idle state (Experiment 2.1 takes data on bank A, and then on bank B)
6. Прогнать двигатели 1,2,4 в режиме малого газа. Двигатель 3 прогревается.			6. Operate engines 1, 2, and 4 in idle state. Engine 3 warms up
7. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=72%. (Для эксперимента 2.1 данные записываются на стороне А, а затем на стороне В) α - угол отклонение рычага упрвления тяги.	5 min	G3	7. Engines 1,2,4 idling. Engine 3 at α=72% (Experiment 2.1 takes data on bank A, and then on bank B). α is throttle lever deflection angle
8. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=98%. (для эксперимента 2.1 настраиваются приборы со стороны А)	20 sec	G4	8. Engines 1,2,4 idling. Engine 3 at α=98% (Experiment 2.1 adjusts instruments on bank A)

Последовательность гонок двигателей с целью измерения шумов в кабине и звуковой нагрузки на обшивку фюзеляжа	**Срок Duration**	**Режим Conditi on**	**Sequence of Engine Ground Run-ups for Measuring Cabin Noise and Sonic Load on Fuselage Skin**
9. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=72%.	30 sec		9. Engines 1,2,4 idling. Engine 3 at α=72%
10. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=98%. (в эксперименте 2.1 записываются данные на стороне A)	20 sec	G4	10. Engines 1,2,4 idling. Engine 3 at α=98% (Experiment 2.1 takes data on bank A)
11. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=72%.	30 sec		11. Engines 1,2,4 idling. Engine 3 at α=72%
12. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=98%. (для эксперимента 2.1 настраиваются приборы со стороны B)	20 sec	G4	12. Engines 1,2,4 idling. Engine 3 at α=98% (Experiment 2.1 adjusts instruments on bank B)
13. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=72%.	30 sec		13. Engines 1,2,4 idling. Engine 3 at α=72%
14. двигатели 1,2,4 работают в режиме малого газа. Двигатель 3 работает при α=98%. (в эксперименте 2.1 записываются данные на стороне B)	20 sec	G4	14. Engines 1,2,4 idling. Engine 3 at α=98% (Experiment 2.1 takes data on bank B)
15. Двигатель 3 перевести на режим малый газ			15. Reduce engine 3 to idle
16. Прогнать двигатели 1,2,3 в режиме малого газа. Двигатель 4 прогревается.			16. Operate engines 1, 2, and 3 in idle state. Engine 4 warms up
17. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=72%. (Для эксперимента 2.1 данные записываются на стороне A, а затем на стороне B)	5 min	G5	17. Engines 1,2,3 idling. Engine 4 at α=72% (Experiment 2.1 takes data on bank A, and then on bank B).
18. двигатели 1,2,3 работают в режиме малого	20 sec	G6	18. Engines 1,2,3 idling. Engine 4 at α=98%

Последовательность гонок двигателей с целью измерения шумов в кабине и звуковой нагрузки на обшивку фюзеляжа	Срок Duration	Режим Conditi on	Sequence of Engine Ground Run-ups for Measuring Cabin Noise and Sonic Load on Fuselage Skin
газа. Двигатель 4 работает при α=98%. (для эксперимента 2.1 настраиваются приборы со стороны А)			(Experiment 2.1 adjusts instruments on bank A)
19. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=72%	30 sec		19. Engines 1,2,3 idling. Engine 4 at α=72%
20. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=98%. (в эксперименте 2.1 записываются данные на стороне А)	20 sec	G6	20. Engines 1,2,3 idling. Engine 4 at α=98% (Experiment 2.1 takes data on bank A)
21. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=72%.	30 sec		21. Engines 1,2,3 idling. Engine 4 at α=72%
22. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=98%. (для эксперимента 2.1 настраиваются приборы со стороны В)	20 sec	G6	22. Engines 1,2,3 idling. Engine 4 at α=98% (Experiment 2.1 adjusts instruments on bank B)
23. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=72%.	30 sec		23. Engines 1,2,3 idling. Engine 4 at α=72%
24. двигатели 1,2,3 работают в режиме малого газа. Двигатель 4 работает при α=98%. (в эксперименте 2.1 записываются данные на стороне В) .	20 sec	G6	24. Engines 1,2,3 idling. Engine 4 at α=98% (Experiment 2.1 takes data on bank B)
25. Двигатель 4 перевести на режим малый газ			25. Reduce engine 4 to idle
Полная продолжительность работы около 45 минут			Total duration approximately 45 minutes
Примечание: двигатели 3 и 4 используются потому, что они расположене с правой стороны, там же где и датчики для эксперимента 2.1.			Note: Engines 3 and 4 are used because they are on the right side which is the same side where Experiment 2.1 transducers are mounted

Последовательность гонок двугателей с целью измерения шумов в кабине и звуковой нагрузки на обшивку фюзеляжа	Срок Duration	Режим Conditi on	Sequence of Engine Ground Run-ups for Measuring Cabin Noise and Sonic Load on Fuselage Skin
Ведущий конструктор (Эксперимент 2.1)			Lead Design Engineer (Experiment 2.1)
			Eduard Andrianov
Начальник отдела СУ			Head of Propulsion
			Shuhayev
Координатор Эксперимента 2.1			Experiment 2.1 Coordinator
			Robert Rackl

Appendix E Reverberation Time Measurement Procedures

1. Turn on instrumentation as per usual procedures.
2. Set up the SD-380 for transient capture.
3. On the Metrum:
    - 3.1. Recall TU-144 MIC CAL setup.
    - 3.2. Put Data Channel Multiplexer on bank B.
    - 3.3. Press INPUT CHAN setup key and enter at TEST NAME (e.g. Reverb Test) by pressing TEST NAME softkey and typing name using keypad.
    - 3.4. Perform a microphone calibration as per usual procedures.
    - 3.5. Increase sampling rate to 160 Ksamples/second/channel for all microphone channels to better capture the waveform.
    - 3.6. **For each test condition**:
        - 3.6.1. Enable only desired microphone channels (23-30), disable others.
        - 3.6.2. Set monitor channels:
            - 3.6.2.1. Press OUTPUT CHAN setup key and set microphone closest to noise source as monitor channel 1 (channel A on SD-380). *(NOTE: Trigger for SD-380 must come on channel A.)*
            - 3.6.2.2. Optionally set up monitor channel 2 (channel B on SD-380) as another microphone.
        - 3.6.3. Set channel input range(s) to ±10V for initial recording.
        - 3.6.4. Press SPEED transport key and ENABLE REC READY softkey to get Metrum ready for acquisition.
        - 3.6.5. Press BAR display key, PEAK HOLD softkey and OVERRANGE CLEAR display key. Press RECORD/PLAY to start acquisition.
        - 3.6.6. When recording starts, give a visual signal that it is OK to fire a blank.
        - 3.6.7. After a couple of seconds following the shot, press STOP.
        - 3.6.8. Enter beginning and ending block number on data sheet.
        - 3.6.9. Look at Overrange Indicator display light to see if any channels overranged. Check out peak on bar display of Metrum. (*) sign indicates the overranged channel(s).
        - 3.6.10. Play back the recorded signal from the Metrum to the SD-380 to verify signal quality.
            - 3.6.10.1. If there any signs of signal clipping or the signal is very low, manually adjust Metrum input range(s) accordingly. *(Note: Make sure signal clipping or low signal level not due to input settings of SD-380, which can also clip or make the signal from the Metrum appear small.)*

3.6.10.2. The play-back speed on the Metrum can be slowed down to better see the captured waveform on the SD-380. This has the effect of changing the time base.

3.6.11. Repeat steps 3.6.4 – 3.6.10 until data is properly recorded on all channels with no clipping or signals too small.

Appendix F Detailed Flight Operational Procedures

0. Введение / 0. Introduction

Редактор, который будет использоваться всеми сторонами для данного процедурного документа будет - Microsoft Word версия 6 для IBM совместимых персональных компьютеров.	The word processor to be used by all parties for this procedures document is Microsoft Word Version 6 for an IBM-compatible personal computer.
Страница формируется как "Landscape" (горизонтально, текст расположен параллельно длинной стороне страницы). Левая часть на русском языке, правая на английском.	The page orientation is 'Landscape' (text runs parallel to the longer side of the sheet). The left half is in Russian, the right half is in English.
Все тексты представлены в виде таблиц. Это облегчает синхронизацию прохождения русской и английской частей текстов вдоль страницы.	All text is organized as word processor tables. This makes it easy to keep Russian and English text synchronized across the pages.
Все боковые поля и горизонтальная разлиновка соответствуют реальному поэтапному описанию процедуры испытаний. Для пояснений и заголовков наносится центральная разделительная линия.	All borders and rulings are visible for actual test procedure step descriptions. Only a center dividing line is visible for explanatory text and headings.
В английской и русской части используется шрифт Pragmatica.	The font on the English and Russian side is Pragmatica.
Размер шрифта для текста 11 точек. Для заголовков - 12 точек с выделением.	The font size for descriptive text is 11 points. For headings it is 12 points and bold.
Ширина колонки "Этапы" - 0,6 дюйма (15,мм), колонки "Описание" - 4,4 дюйма (111,8мм, а колонки "Отметок о выполнении - √" - 0,6 дюйма (15,2мм).	The width for the 'Step' column is 0.6 inches (15.2 mm); the width of the 'Description' column is 4.4 inches (111.8 mm). The width of the checkmark column is 0.6 inches (15.2 mm).
В данном документе содержится только текстовой материал (без графиков или изображений). Возможны ссылки на чертежи/изображения/рисунки. Эти материалы будут собираться в отдельную подборку.	This document contains only text (no graphics or pictures). Drawings/sketches/pictures can be referred to; they will be collected in a separate binder.
"Односторонние материалы" - при копировании должна использоваться лишь одна сторона страницы.	'Single sided': When making copies, only one side of each sheet of paper is used.
Поля выставляются в зависимости от используемого формата бумаги - американского или европейского. Для сохранения размерности и пропорциональности текста с таблицами использовать следующие поля:	The margins depend on whether US or European sheet sizes are used. In order to keep the size and proportions of the text and tables the same the following margins should be used:

0. Введение

Бумага формата А-4 (297x210мм=11,69x8,27дюйма)
верх: 19,05мм (0,75дюйма)
низ: 14,15мм (0,56 дюйма)
лево-право: 21,5мм (0,85 дюйма)

Бумага формата 8,5x11 дюймов (215,9x279,4 мм)
верх: 0,75дюйма (19,05мм)
низ: 0,75дюйма (19,05 мм)
лево-право: 0,5дюйма (12,7 мм)

При изменении формата бумаги установить поля в соответствии с вышеприведенной размерностью!

Замечания по поводу слов, *выделенных наклонным шрифтом*: этим шрифтом напечатаны слова, которые в русском тексте должны быть сохранены латинскими буквами, так как они обозначают метки на оборудовании.

Этот документ "защищен от ревизий": для " принятия" ревизии требуется пароль. Для контроля процесса обновления документа этот пароль известен только координатору эксперимента с американской стороны.

0. Introduction

For sheet size A4 (297 x 210 mm = 11.69 x 8.27 inches):
Top: 19.05 mm (0.75 inches)
Bottom: 14.15 mm (0.56 inches)
Left and right: 21.5 mm (0.85 inches)

For sheet size 8.5x11 inches (215.9 x 279.4 mm):
Top: 0.75 inches (19.05 mm)
Bottom: 0.75 inches (19.05 mm)
Left and right: 0.5 inches (12.7 mm)

When you change paper size adjust the margins according to above measurements!

Meaning of *italicized* words: they refer to English words that must be copied to the Russian text verbatim without translation because they appear as labels on the instrumentation.

The document is ‘protected for revisions’: a password is required to ‘accept’ revisions. In order to control the updating process this password is only known to the experiment coordinator of the US Team.

РЕВИЗИИ ЭТОГО ДОКУМЕНТА

(1) Сделайте копию компьютерного файла, который вы пересматриваете.

(2) Присвойте этой копии новое имя путем изменения последней буквы, например, PROC144A.DOC на PROC144B.DOC

(3) Откройте новый файл в MS WORD 6. Если нужно, нажмите клавишу "Cancel" в аналоговом окне "Unprotect Document" (незащищенный документ), когда у вас спрашивают пароль.Эта особенность управления разрешается только координатору эксперимента,чтобы "принять" ревизию. Отметим, что это диалоговое окно может появиться более одного раза, когда открывается этот документ. Продолжите вход нажав "Cancel".

(4) Обновите название файла и дату последней ревизии в подзаголовках каждой секции документа.

(5) Перед тем как делать какие-либо изменения, убедитесь в том, что:

- Флажок проверен (включенным) следующий за 'Изменения Метки(указателя) При Редактировании' ('Mark Revisions While Editing') в блоке диалога Revisions Инструментальных средств меню

- под таблицей "Revisions"из диалогового окна "Options"в меню "Tools"вставляемый текст отмечается подчеркиванием, исключаемый текст отмечается перечеркиванием и линии ревизии находятся на левой границе листа.Кроме того, цвет, которым показываются на экране ревизии, определяет автора внесенных изменений

(6) Если вы сделали работу по переводу документа, просто добавьте новый текст и через Word 6. отметьте изменения

REVISIONS TO THIS DOCUMENT:

(1) Make a copy of the computer file you are revising.

(2) Give the copy a new name by incrementing the last letter; for example, PROC144A.DOC becomes PROC144B.DOC.

(3) Open the new file in MS Word 6. If required, press the 'Cancel' button on the 'Unprotect Document' dialog box when asked for the password. This feature allows only the Experiment Coordinator to 'accept' revisions. Note that this dialog box may appear more than once when opening the document. Continue to enter 'Cancel'.

(4) Update the filename and date of last revision in the footers of each section of the document.

(5) Before making any changes be sure that:

- the check box is checked (turned on) next to 'Mark Revisions While Editing' in the Revisions dialog box of the Tools drop-down menu.

- on the 'Revisions' tab of the 'Options...' dialog box of the 'Tools' drop-down menu, inserted text is marked by underlines, deleted text is marked by strikethroughs, and revised lines are marked on the left border. Also, the color by which revisions are shown on the screen should be 'Author' for insertions and deletions; this will help track which organization made changes to the document.

(6) If you are doing translation work on the document, simply add the new text and allow Word 6 to mark the changes.

ОТМЕТКА О РЕВИЗИИ		REVISION RECORD	
Дата	Происхождение ревизии	Date	Nature of Revision
1997/04/04	В ответ на факс от АНТК им.А.Н.Туполева от 24 мая 1996г.(BO-TU-353 от 28 мая 1996г.)	1997/04/04	In response to fax from Tupolev of 1996 May 24 (BO-TU-353 of 1996 May 28)
1997/09/27	После поездки в Москву Июля-Августа американских специалистов Экцперимента 2.1 -> PROC144J.DOC	1997/09/27	After the July/August trip of the Experiment 2.1 US Team to Moscow -> PROC144J.DOC
1997/10/19	-> PROC144K.DOC	1997/10/19	Added section 3.2.16 at the request of Tupolev operator -> PROC144K.DOC

Сокращения		ABBREVIATIONS	
AC	Переменный ток	AC	Alternating Current
APU	ВСУ	APU	Auxiliary Power Unit
B&K	Брюль и Кьер	B&K	Bruel & Kjaer
CHAN	Канал	CHAN	Channel
dB	Дб	dB	Decibel(s)
DC	Постоянный ток	DC	Direct Current
DECR	Уменьшение	DECR	Decrement
ECS	СКВ (система кондицирования воздуха)	ECS	Environmental Control System (air conditioning)
Hz	Гц	Hz	Hertz
INCR	Увеличение	INCR	Increment
IRIG-B	Код времени IRIG	IRIG-B	(an electronic interface/communications standard)
kHz	кГц	kHz	Kilo Hertz
КЗА		INSTRUMENTATION	
MIC CAL	Калибровка микрофона	MIC CAL	Microphone Calibration
MSL	Относительно уровня моря	MSL	Mean Sea Level (altitude above)
REC	Запись, магнитофон	REC	Recorder, recording
REW	Перемотка назад	REW	Rewind
VDC	Вольт, постоянный ток	VDC	Volts of Direct Current

0. Введение / 0. Introduction

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0. Введение / 0. Introduction

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Примечание:	**1.0**		**Note**
Работы по секциям с 1. по 1.6 включительно выполняются американскими специалистами совместно со специалистами АНТК им. А.Н.Туполева.			The work in sections 1. through 1.6, inclusive, will be performed by the US Team with the support of Tupolev personnel.

Проверка	**1.1**		**Inspection**
Описание	**Этап**	√(1)	**Description**
Проверить надлежащее крепение этажерки КЗА к полу.	1.1.1		Verify instrumentation pallet is properly anchored to the floor.
Проверить этажерку КЗА на очевидные механические повреждения. Об обнаруженных повреждениях немедленно сообщить ответственному за эксперимент 2.1.	1.1.2		Inspect instrumentation pallet for any obvious mechanical damage. Bring any damage to the attention of the Experiment 2.1 test director immediately.
Убедиться, что верх этажерки КЗА свободен для выпуска охлаждающего воздуха, а низ этажерки не загроможден для доступа охлаждающего воздуха.	1.1.3		Verify instrumentation pallet top is free to expel cooling air and bottom of instrumentation pallet is unobstructed to take in cooling air.
Проверить присоединение внешних кабелей (постоянного тока, переменного тока, кода времени IRIG-B / предоставляются АНТК) к этажерке КЗА.	1.1.4		Verify external (Tupolev supplied) cables are connected to instrumentation pallet: AC power, DC power, IRIG-B Time Code.
Проверить наличие расходных материалов: (6) кассет с чистой записывающей пленкой (каждая из них пронумерована индивидуальным идентификационным номером), бумага для заметок, ручки, карандаши, 10 чистых листков технических данных для записи показаний при получении данных. Расходные материалы хранить в ящиках этажерки.	1.1.5		Verify the following supplies are available: (6) cassettes of blank recording tape (each labelled with a unique identification number), note paper, pens/pencils, 10 blank data sheets to record settings during data acquisition. Store supplies in instrumentation pallet drawers.

1. Предполетная Процедура

1. Pre-Flight Procedures

Проверка	1.1		Inspection
Описание	**Этап**	**√(1)**	**Description**
Убедиться, что приборы на этажерке как следует закреплены (не болтаются). Убедиться, что внутри этажерки отсутствуют посторонние предметы и они не соприкасаются с этажеркой.	1.1.6		Verify instruments in the pallet are properly mounted (nothing loose). Verify that no foreign objects are inside or are touching the instrumentation pallet.
Проверить систему микрофонов.	1.1.7		Inspect the microphone subsystem:
Проверить на этажерке все удлинительные кабели микрофонов. Убедиться, что они не повреждены и закреплены.	1.1.7.1		Inspect all microphone extension cables at the pallet. Verify all are secure and free from damage.
Проверить все удлинительные кабели микрофонов между этажеркой и предусилителями микрофонов. Убедиться, что они правильно уложены и закреплены, а разрывы и необычные изгибы отсутствуют. Проверить соединения между удлинительными кабелями и состояние пластмассовых трубок, покрывающих эти соединения.	1.1.7.2		Inspect all microphone extension cables between pallet and microphone preamplifiers. Verify all are properly laid and strapped down and are free of breaks or unusual kinks. Verify connections between extension cables and inspect plastic tubing that covers these connections
Проверить правильность установки предусилителей микрофонов. Убедиться, что микрофон в кабине расположен достаточно близко к уху пилота, но не мешает ему.	1.1.7.3		Verify all microphone preamplifiers are properly mounted. Verify the cockpit microphone is close to pilot's ear but does not disturb the pilot.
Убедиться, что все микрофоны надежно подсоединены к предусилителям микрофонов.	1.1.7.4		Verify all microphone cartridges are securely connected to the microphone preamplifier.
Проверить подсистему акселерометров.	1.1.8		Inspect the accelerometer subsystem:
Проверить все места кабельных стыковок на этажерке. Убедиться, что они надежно закреплены и не повреждены.	1.1.8.1		Inspect all interface cable connections at the pallet. Verify all are secure and free from damage.

Проверка	1.1		Inspection
Описание	**Этап**	√(1)	**Description**
Проверить все соединительные кабели между этажеркой и дистанционными блоками предварительного формирования сигналов. Убедиться, что все они правильно уложены и закреплены, а разрывы и необычные изгибы отсутствуют.	1.1.8.2		Inspect all interface cables between pallet and remote signal conditioning units. Verify all are properly laid and strapped down and are free of breaks or unusual kinks.
Проверить шесть (6) блоков формирования сигнала акселерометра. Убедиться, что блоки надлежащим образом прикреплены к опорам.	1.1.8.3		Inspect the six (6) remote accelerometer signal conditioning units. Verify units are properly attached to their supports.
Проверить все места соединений кабелей дистанционных блоков формирования сигналов.	1.1.8.4		Inspect all interface cable connections at the remote signal conditioning units. Verify all are secure and free from damage.
Проверить все кабельные соединения датчиков на дистанционных блоках формирования сигналов. Убедиться, что они надежно закреплены и не повреждены.	1.1.8.5		Inspect all transducer cable connections at the remote signal conditioning units. Verify all are secure and free from damage.
Проверить все кабели датчиков между дистанционными блоками формирования сигналов и датчиками. Убедиться в правильной укладке и закреплении, отсутствии разрывов и необычных изгибов.	1.1.8.6		Inspect all transducer cables between the remote signal conditioning units and the transducer. Verify all are properly laid and strapped down and are free of breaks or unusual kinks.
Проверить подсистему датчиков давления KULITE.	1.1.9		Inspect the Kulite pressure transducer subsystem:
Проверить все соединения кабелей на этажерке. Убедиться в том, что они изолированы и не повреждены.	1.1.9.1		Inspect all interface cable connections at the pallet. Verify all are secure and free from damage.

1. Предполетная Процедура

1. Pre-Flight Procedures

Проверка	1.1		Inspection
Описание	**Этап**	√(1)	**Description**
Проверить все кабели интерфейсов между этажеркой и дистанционными блоками формирования сигналов. Убедиться в их правильной укладке и закреплении, отсутствии разрывов и необычных изгибов.	1.1.9.2		Inspect all interface cables between pallet and remote signal conditioning units. Verify all are properly laid and strapped down and are free of breaks or unusual kinks.
Проверить три (3) дистанционных блока формирования сигнала KULITE. Убедиться в их надлежащем креплении к опорам.	1.1.9.3		Inspect the three (3) remote Kulite signal conditioning units. Verify units are properly attached to their supports.
Проверить все соединения кабельных интерфейсов на дистанционных блоках формирования сигнала. Убедиться, что они закреплены и не повреждены.	1.1.9.4		Inspect all interface cable connections at the remote signal conditioning units. Verify all are secure and free from damage.
Проверить все соединения кабелей датчиков на дистанционных блоках формирования сигналов. Убедиться, что они закреплены и не повреждены.	1.1.9.5		Inspect all transducer cable connections at the remote signal conditioning units. Verify all are secure and free from damage.
Проверить все кабели датчиков между блоками формирования сигналов и датчиком. Убедиться в их правильной укладке и закреплении, отсутствии разрывов и необычных изгибов.	1.1.9.6		Inspect all transducer cables between the remote signal conditioning units and the transducer. Verify all are properly laid and strapped down and are free of breaks or unusual kinks.
Убедиться в том, что трубки компенсации давления в кабине на датчиках динамического давления KULITE не засорены.	1.1.9.7		Verify Kulite pressure transducer reference tubes that vent to aircraft interior are free from obstructions.
Убедиться, что датчики давления KULITE закреплены в держателях.	1.1.9.8		Verify Kulite pressure transducers are secured in holders.
Убедиться, что держатели KULITE закреплены в фальшиллюминаторах.	1.1.9.9		Verify Kulite holders are secure in window blanks.
Убедиться, что все внешнее защитное покрытие (крышки) снято с датчиков KULITE. (эту операцию следует проделать на кануне дня полета).	1.1.9.10		Verify all exterior protective covers have been removed from Kulite transducers. (This should be done prior to day of flight).

Проверка	1.1		Inspection
Описание	**Этап**	√(1)	**Description**
Проверить погодные условия: убедиться, что датчики KULITE не намокнут при пробежке, взлете и подъеме в тропосфере.	1.1.10		Check weather conditions: Verify Kulites will not get wet during taxi, takeoff, and tropospheric climb.

Включение электропитания этажерки	**1.2**		**Turn on Electrical Power to Rack**
Описание	**Этап**	√	**Description**
Убедиться, что питание подается к этажерке КЗА. Загорится желтый индикатор SHIPS 115V 400Hz (Box 101), загорится зеленый индикатор SHIPS 27V DC (Box 101).	1.2.1		Verify power available to instrumentation pallet. *SHIPS 115V 400 Hz* amber indicator light is lit (*BOX* 101). *SHIPS 27 VDC* green indicator light is lit (*BOX* 101).
Убедиться, что задействованы (вдавлены) все выключатели (прерыватели на Box 101, за исключением выключателей с белым кольцевым выступом).	1.2.2		Verify all breakers engaged (pushed in) on *BOX* 101 except those with white collars.
Поставить красный предохранительный переключатель 115V 400Hz и тумблер в положение ON на Box 104.	1.2.3		Switch *115V 400 Hz* red switch guard and toggle switch to *ON* position on *BOX* 104.
Поставить красный предохранительный переключатель SIGNAL ANALYZER POWER и тумблер в положение ON на Box 104.	1.2.4		Switch *SIGNAL ANALYZER POWER* red switch guard and toggle switch to *ON* position on *BOX* 104.
Поставить красный предохранительный переключатель 27V DC в положение ON на Box 104.	1.2.5		Switch *27 VDC* red switch guard to *ON* position on *BOX* 104.
Для включения питания этажерки КЗА вытянуть вверх до положения ON тумблер MASTER POWER (Box 104).	1.2.6		Pull out and up on *MASTER POWER* toggle switch to *ON* position to power-up instrumentation pallet (*BOX* 104).
По трем зеленым индикаторам проверить подачу питания. Один- для MASTER POWER, второй - для 27 V DC (Box 104)µ третй - 115V 400 Гц.	1.2.7		Verify power on with three green lights; one for *MASTER POWER*, one for *27 VDC, one for 115V 400 Hz* (*BOX* 104).

Включение электропитания этажерки	**1.2**		**Turn on Electrical Power to Rack**
Описание	**Этап**	√	**Description**
Включите питание мультиплексера микрофонов B&K(Box 203)/ Откиньте вниз защитную пластмассовую крышку и тумблер "Power" переведите в положение "On" (верх). Как только питание будет подведено к этому блоку над надписью "On" загориться красная лампочка. Поднимите вверх защитную пластмассовую крышку. Если необходимо,то запасной мультиплексер (BOX 202) может быть подключен таким же образом. Выключатель на Box 203 обычно остается в положении ON.	1.2.8		Turn on power to B&K microphone multiplexer (*BOX* 203). Lower protective plastic cover and switch *Power* toggle switch to *On* (up) position. Red light will appear above *On* label when power has been supplied to the unit. Raise protective plastic cover. Spare multiplexer (*BOX* 202) will be powered up in the same manner only if necessary. The power switch on Box 203 is normally left in the ON position
Проверить работу охлаждающих вентиляторов в верхней части этажерки КЗА.	1.2.9		Verify cooling fans on top of pallet are running.

Проверка КЗА	**1.3**		**Instrumentation Check**
Описание	**Этап**	√	**Description**
Проверить подачу питания к магнитофону METRUM (Box 207) и анализатору спектра SD-380 (Box 105). Тумблер питания на магнитофоне METRUM (BOX 207) обычно находится в левом положении при включенном питании (ON). METRUM включается и выключается подачей питания 115В 400Гц на блоке 104. Если тумблер питания находится в положении "выключено" (Off) его необходимо перевести в положение "включено" (On) (правое). Выключатель питания находится в верхнем правом углу магнитофона. Тумблер питания анализатора спектра SD-380(BOX 105) не доступен с передней панели КЗА он находится во включенном положении. SD-380 включается и выключается только путем подачи питания на блоке 104 (BOX 104).	1.3.1		Verify power to *METRUM* recorder (*BOX* 207) and SD-380 spectrum analyzer (*BOX* 105). The power switch on the *METRUM* recorder (*BOX* 207) is normally left in the *ON* position. The *METRUM* is turned on and off using the *115V 400 Hz* power switch on *BOX* 104. In the event the power switch on the *METRUM* recorder has been turned off, it may be turned on again by pressing the power rocker switch to the *ON* (right) position. The power rocker switch is located in the upper right hand corner of the *METRUM*. The power switch on the SD-380 spectrum analyzer (*BOX* 105) is not accessible on the front of the instrumentation pallet. It is normally left in the on position. The SD-380 is turned on and off using only the *SIGNAL ANALYZER POWER* switch on *BOX* 104.
Убедиться, что дисплей кода времени (Box 106) работает в соответствии с сигналом, производимым на самолете. Для синхронизации сигнала требуется примерно одна минута.	1.3.2		Verify time code display (*BOX* 106) working and in agreement with ship's generated signal. Signal takes roughly 1 minute to synchronize.
Убедиться, что время на часах METRUM соответствует времени на дисплее IRIG B TIME CODE DISPLAY. Время METRUM демонстрируется на первичном пусковом экране. При несовпадении времени проделать следующие операции:	1.3.3		Check *METRUM* clock to see that it corresponds with the time on the *IRIG B TIME CODE DISPLAY*. *METRUM* time is displayed on initial startup screen. If there is a discrepancy, perform the following operations:
Нажать кнопку MENU в секции SYSTEM FUNCTIONS	1.3.3.1		Press *MENU* button in *SYSTEM FUNCTIONS* section.
Использовать CURSOR для выделения SET CLOCK	1.3.3.2		Use *CURSOR* to highlight *SET CLOCK*.

Проверка КЗА	**1.3**		**Instrumentation Check**
Описание	**Этап**	√	**Description**
Нажать клавишу SELECT ITEM	1.3.3.3		Press *SELECT ITEM* softkey.
Сравнить время CURRENT CLOCK с временем на дисплее IRIG B TIME CODE DISPLAY.	1.3.3.4		Compare *CURRENT CLOCK* time with the IRIG B TIME CODE DISPLAY.
Использовать CURSOR для выделения времени TIME, затем ввести правильное время с помощью кнопок с цифрами в секции VALUE ENTRY. Нажать кнопку ENTER в секции VALUE ENTRY.	1.3.3.5		Use *CURSOR* to highlight *TIME*, then enter correct time with numbered buttons in *VALUE ENTRY* section. Press *ENTER* button in *VALUE ENTRY* section.
Нажать клавишу SET CLOCK, затем клавишу DONE.	1.3.3.6		Press *SET CLOCK* softkey, then *DONE* softkey.
Вставить новую пленку в магнитофон METRUM, нажать кнопку DIRECTORY в секции SYSTEM FUNCTIONS, затем нажать клавишу READ EOD DIR.	1.3.4		Insert new tape into *METRUM* recorder, press *DIRECTORY* button in *SYSTEM FUNCTIONS* section, then press *READ EOD DIR* softkey.

Проверка METRUM голосом.	**1.4**		***METRUM* Voice Check**
Описание	**Этап**	√	**Description**
Подсоединить усилитель голосового микрофона ~~голоса~~ к каналу 32 магнитофона METRUM. Прикрепить прищепкой ~~прицепительный~~ микрофон к одежде приблизительно 10 cm ото рта.	1.4.1		Hook up voice microphone amplifier to *METRUM* recorder channel 32. Attach clip-on voice microphone to clothing approximately 4-inches (10 cm) from mouth.
Нажать кнопку MEMORY в секции SET UP и при помощи курсора высветить установленное название TU-144 Flight Test. Нажать клавишу RECALL SET UP, а затем RECALL.	1.4.2		Press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 FLIGHT TEST* setup name. Press *RECALL SETUP* softkey, then *RECALL* softkey.
Нажать кнопку BAR в секции DISPLAY и перевести курсор на канал 32.	1.4.3		Press *BAR* button in *DISPLAY* section and move cursor to channel 32.

Проверка METRUM голосом.	**1.4**		***METRUM* Voice Check**
Описание	**Этап**	√	**Description**
Нажать тумблер усилителя голосового микрофона для установления контакта и удержать его. Говорить также, как и во время полета, и следить за дисплеем шкалы на METRUM. Если показания шкалы слишком малые или слишком большие, переставить CURSOR вниз на VOLTS PEAK и отрегулировать уровень при помощи кнопок INCR и DECR в секции VALUE ENTRY. По окончании отпустить тумблер на усилителе микрофона голоса.	1.4.4		Press toggle switch on voice microphone amplifier to momentary on position and hold. Talk as you would during flight and observe the bar display on the *METRUM*. If bar is under- or over-ranging, move *CURSOR* down to *VOLTS PEAK* and adjust level using *INCR* and *DECR* buttons in *VALUE ENTRY* section. Release the toggle switch on voice microphone amplifier when finished.
Если уровни установлены, нажать кнопку MEMORY в секции SET UP и использовать CURSOR для выделения установленного названия TU-144 Flight Test. Нажать клавишу SAVE SET UP, а затем SAVE.	1.4.5		If levels were adjusted, press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 FLIGHT TEST* setup name. Press *SAVE SETUP* softkey, then *SAVE* softkey.
Отсоединить разъем выхода усилителя голосового микрофона, оставив короткий кабель, присоединенный к каналу 32 METRUM. Закрепить усилитель голосового микрофона и прикрепляющийся микрофон для использования оператором.	1.4.6		Disconnect voice microphone amplifier output jack, leaving short cable connected to *METRUM* channel 32. Secure voice microphone amplifier and clip-on microphone for use by operator.

Калибровка микрофонов	**1.5**		**Microphone Calibration**
Описание	**Этап**	√	**Description**
До продолжения работ дать микрофонам прогреться в течение двух часов, начиная с п. 1.2.8.	1.5.0		Before proceeding further, allow 2 hours for warm-up of microphones, starting from step 1.2.8.
Установить калибратор на 1kHz и 114dB для следующих калибровок.	1.5.1		Set calibrator on 1 kHz and 114 dB for the following calibrations.

Калибровка микрофонов	**1.5**		**Microphone Calibration**
Описание	**Этап**	√	**Description**
Установить DATA CHANNEL MULTIPLEXER SELECTOR на BANK B (Box 104).	1.5.2		Set *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK B* (*BOX* 104).
Нажать кнопку MEMORY в секции SET UP и использовать CURSOR для выделения установленного названия TU-144 MIC CAL. Нажать клавишу RECALL SET UP, затем RECALL.	1.5.3		Press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 MIC CAL* setup name. Press *RECALL SETUP* softkey, then *RECALL* softkey.
Для каждого из 8 микрофонов записать сигнал калибратора в течение тридцати (30) секунд на магнитофон METRUM. На METRUM отключить все входящие каналы (при помощи меню INPUT CHAN), за исключением калибруемого канала микрофона. Сделать отметку в дневнике калибровки микрофона. Примечание: замерить выход канала на SD-380 и подождать до установки компенсации постоянного тока, перед тем как начать накапливать данные.	1.5.4		Overview: For each of the 8 microphones, record the calibrator signal for thirty (30) seconds on the *METRUM* recorder. Turn off all input channels on *METRUM* (using *INPUT CHAN* menu) except for microphone channel being calibrated. Fill in microphone calibration log sheet. Operation requires two people: calibrator operator (OPC), instrumention rack operator (OPR). Use radio telephones to communicate.(Note: Monitor output channel on SD-380 and wait until DC offset settles out before acquiring data.)
	1.5.4.1		OPR: Obtain current atmospheric pressure from flight personnel and record on data sheet. Obtain current cabin interior temperature and record on data sheet.
	1.5.4.2		OPC: move to next microphone. OPR: turn off all channels on METRUM except for microphone being calibrated.
	1.5.4.3		OPR: enter Test Name (INPUT CHAN screen)
	1.5.4.4		OPR: connect METRUM output channel to input channel being calibrated (OUTPUT CHAN screen)
	1.5.4.5		OPC: make sure calibrator is OFF. Avoid static electricity discharge. Slip calibrator gently over microphone. Select 1 KHz. Turn ON to 114 dB.

Калибровка микрофонов	**1.5**		**Microphone Calibration**
Описание	**Этап**	√	**Description**
	1.5.4.6		OPR: On METRUM bar display select the channel being calibrated and determine proper range setting.
	1.5.4.7		OPR: On SD-380 watch signal (nice sine wave?). Wait for DC component to die out.
	1.5.4.8		OPR: Write down beginning block number
	1.5.4.9		OPR: Record signal on METRUM for 30 seconds
	1.5.4.10		OPR: Tell OPC to turn calibrator off OPC: Avoid static electricity discharge. Gently remove calibrator from microphone.
	1.5.4.11		OPR: Write down ending block number and other relevant information
Нажать кнопку MEMORY в секции SET UP и при помощи CURSOR высветить установленное название TU-144 Flight Test. Нажать клавишу RECALL SET UP, а затем RECALL. Примечание: это делается в рамках подготовки к летным измерениям.	1.5.5		Press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 FLIGHT TEST* setup name. Press *RECALL SETUP* softkey, then *RECALL* softkey. (Note: This is in preparation for the flight test measurements)
(По выбору) Нажать кнопку INPUT CHAN в секции SET UP и клавишу TEST NAME. Используя клавиатуру, напечатать название теста.	1.5.6		(Optional) Press *INPUT CHAN* button in *SETUP* section and *TEST NAME* softkey. Type in a test name using keypad.
Вытянуть предохранутель CB5 и закрыть его белым колпачком (Box 101).	1.5.7		Pull CB5 breaker and secure it with a white collar (*BOX* 101).

Переход с наземного питания на вспомогательный блок питания ВСУ	**1.6**		**Switch Power from Ground Power to APU**
Описание	**Этап**	√	**Description**
Отменяется	1.6.1		DELETED
До переключения питания с наземного на вспомогательный блок питания ВСУ экипаж самолета в кабине или на Земле предупреждает об этом оператора.	1.6.2		Cockpit/ground crew informs operator prior to switching power from ground power to APU.
Непосредственно перед переключением наземного питания на вспомогательный блок питания (ВСУ), вытянуть и поставить вниз тумблер MASTER POWER в положение OFF (Box 104).	1.6.3		Just before power is switched from ground power to APU, pull out and down on *MASTER POWER* toggle switch to *OFF* position (*BOX* 104).
После переключения питания на ВСУ вытянуть и поставить MASTER POWER в верхнее положение ON, для подачи питания к этажерке КЗА (Box 104).	1.6.4		After power has been switched to APU, pull out and up on *MASTER POWER* toggle switch to *ON* position to power up instrumentation pallet (*BOX* 104).
Проверить подачу питания по трем зеленым индикаторам: один- для MASTER POWER, второй - для 115V 400Hz, третий - для 27 V DC.	1.6.5		Verify power on with three green lights; one for *MASTER POWER*, one for *115V 400 Hz*, one for *27 VDC* (*BOX* 104).
Убедиться, что работают охлаждающие вентиляторы в верхней части этажерки КЗА.	1.6.6		Verify cooling fans on top of pallet are running.

Примечание:	**2.0**		**Note**
Работы по секциям с 2. по 2.8 включительно выполняются американскими специалистами совместно со специалистами АНТК им. А.Н.Туполева.			The work in sections 2. through 2.8, inclusive, will be performed by the US Team with the support of Tupolev personnel.

Принятие решения лететь/не лететь	**2.1**		**Go-No Go Decision**
Описание	**Этап**	√	**Description**
Проверить перечень критических параметров	2.1.1		Check critical parameters list.
Если все в порядке, сообщить экипажу кабины и ответственному за проведение эксперимента, что эксперимент 2.1 готов для записи данных.	2.1.2		If everything is OK, tell cockpit/test director that Experiment 2.1 is ready to take measurements.

Переключение питания с ВСУ на генератор.	**2.2**		**Switch Power from APU to Generator**
Описание	**Этап**	√	**Description**
До переключения питания с ВСУ на питание от генератора самолета, экипаж извещает об этом оператора.	2.2.1		Cockpit informs operator prior to switching power from APU to ship's generator.
Непосредственно перед переключением питания с ВСУ на генератор самолета, втянуть вниз тумблер MASTER SWITCH и установить его в положение OFF (Box 104).	2.2.2		Just before power is switched from APU to ship's generator, pull out and down on *MASTER POWER* toggle switch to *OFF* position (*BOX* 104).
После переключения питания на генератор самолета, вытянуть вверх тумблер MASTER SWITCH в положение ON для подачи питания к этажерке КЗА (Box 104).	2.2.3		After power has been switched to ship's generator, pull out and up on *MASTER POWER* toggle switch to *ON* position to power up instrumentation pallet (*BOX* 104).

Переключение питания с ВСУ на генератор.	**2.2**		**Switch Power from APU to Generator**
Описание	**Этап**	√	**Description**
Проверить подачу питания по трем зеленым индикаторам: один для MASTER POWER, второй для 115V 400Hz, третий для 27V DC(Box 104).	2.2.4		Verify power on with three green lights; one for *MASTER POWER*, one for *115V 400 Hz*, one for *27 VDC* (*BOX* 104).
Убедиться, что работают охлаждающие вентиляторы в верхней части этажерки КЗА.	2.2.5		Verify cooling fans on top of pallet are running.

Проверка голосовой связи с кабиной и прикрепление голосового микрофона магнитофона METRUM.	**2.3**		**Cockpit Voice Check and METRUM Voice Microphone Hook-up**
Описание	**Этап**	√	**Description**
Проверить двустороннюю связь с экипажем в кабине.	2.3.1		Confirm two-way intercom with cockpit.
Прикрепить кабель, подсоединенный к 32 каналу магнитофона METRUM к выходу усилителя голосового микрофона и закрепить голосовой микрофон к одежде примерно в 4-х дюймах (10см) от рта.	2.3.2		Hook up cable connected to *METRUM* recorder channel 32 to voice microphone amplifier output jack. Attach clip-on voice microphone to clothing approximately 4-inches (10 cm) from mouth.

Наземные измерения (Режим испытаний #G1) (Самолет на стоянке, Двигатели на холостом ходу, СКВ включена)	**2.4**		**Ground Measurements (Test Condition #G1) (Stationary Aircraft, Engines Idling, ECS On)**
Описание	**Этап**	√	**Description**
Проверить, что СКВ (система кондиционирования воздуха) работает на полную мощность.	2.4.1		Verify that ECS (Environmental Control System = air conditioning) is generating at full capacity.

Наземные измерения (Режим испытаний #G1) (Самолет на стоянке, Двигатели на холостом ходу, СКВ включена)	**2.4**		**Ground Measurements (Test Condition #G1) (Stationary Aircraft, Engines Idling, ECS On)**
Описание	**Этап**	√	**Description**
На магнитофоне METRUM (Box 207) нажать кнопку SPEED секции TRANSPORT, а затем клавишу ENABLE RECORDING. До продолжения операций убедиться в том, что надпись READY появилась в верхнем правом углу экрана.	2.4.2		On *METRUM* (*BOX* 207) , press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	2.4.3		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На новом справочном листке технических данных записать название кассеты, число, номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока. Примечание: текущий номер испытания является простым способом идентификации определенной записи. Текущий номер испытания увеличивается при каждой произведенной записи. Отсчет номера испытания никогда не возвращается к 1 и будет возрастать даже для кассет с данными и от полета к полету. Примечание: Номер блока указывается под надписью READY в верхнем правом углу экрана. Примечание: Название кассеты можно найти, нажав кнопку DIRECTORY в секции SYSTEM FUNCTIONS. Название кассеты CASSETTE NAME появляется рядом с верхним левым углом экрана.	2.4.4		On a new data sheet, record cassette name and date, run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number. (Note: The run number is an easy means of identifying a particular record. The run number is incremented for each record taken. The run number count is never reset to 1 and will increase even across data cassettes and flights.) (Note: The block number is found just below the *READY* message in the top right corner of the screen). (Note: The cassette name can be found by pressing the *DIRECTORY* button in *SYSTEM FUNCTIONS* section. *CASSETTE NAME* is near the upper left corner of the screen.)

Наземные измерения (Режим испытаний #G1) (Самолет на стоянке, Двигатели на холостом ходу, СКВ включена)	**2.4**		**Ground Measurements (Test Condition #G1) (Stationary Aircraft, Engines Idling, ECS On)**
Описание	**Этап**	√	**Description**
Для автоматического переключения диапазона измерений уровня входящего сигнала на METRUM проделать следующие операции:	2.4.5		Perform the following procedures to autorange the input level on the *METRUM* :
Нажать кнопку BAR в секции DISPLAY;	2.4.5.1		Press *BAR* button in *DISPLAY* section.
Нажать клавиши AUTORANGE SOFTKEYS (после нажатия клавиши должны загораться).	2.4.5.2		Press *AUTORANGE SOFTKEYS* softkey (softkey should be lit after pressing).
Нажать клавишу ENABLE AUTORANGE и подождать пока погаснет освещение клавиши ENABLE AUTORANGE.	2.4.5.3		Press *ENABLE AUTORANGE* softkey and wait until *ENABLE AUTORANGE* softkey light turns itself off.
Нажать клавишу AUTORANGE MODE (после нажатия клавиша должна загореться).	2.4.5.4		Press *AUTORANGE MODE* softkey (softkey should be lit after pressing).
Нажать кнопку INCR в секции VALUE ENTRY для переключения в режим автоматического переключения диапазона измерений -CONTINUOUS.	2.4.5.5		Press *INCR* button in *VALUE ENTRY* section to switch to *CONTINUOUS* autorange mode.
Нажать клавишу ENABLE AUTORANGE (клавиша должна загореться после нажатия) и подождать 10 секунд.	2.4.5.6		Press *ENABLE AUTORANGE* softkey (softkey should be lit after pressing) and wait 10 seconds.
Для отмены команды нажать клавишу ENABLE AUTORANGE еще раз. После нажатия клавиша должна погаснуть.	2.4.5.7		Press *ENABLE AUTORANGE* softkey again to disable. Softkey should be unlit after pressing.
Нажать кнопку DECR в секции VALUE ENTRY для переключения в режим BRIEF - автоматического переключения диапазона измерений.	2.4.5.8		Press *DECR* button in *VALUE ENTRY* section to switch to *BRIEF* autorange mode.
Нажать клавишу AUTORANGE SOFTKEYS для выхода из режима автоматического переключения диапазона измерений (после нажатия клавиша должна погаснуть).	2.4.5.9		Press *AUTORANGE SOFTKEYS* softkey to exit autorange function (softkey should be unlit after pressing).

Наземные измерения (Режим испытаний #G1) (Самолет на стоянке, Двигатели на холостом ходу, СКВ включена)	**2.4**		**Ground Measurements (Test Condition #G1) (Stationary Aircraft, Engines Idling, ECS On)**
Описание	**Этап**	√	**Description**
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать и удерживать кнопку RECORD. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки. Примечание: клавиши OVERRANGE CHECKING и OVERRANGE HOLD должны загореться. Если они не загорятся, на них следует нажать. Примечание: при подготовке METRUM к записи в течение нескольких секунд будет мигать красный индикатор, в верхнем правом углу экрана замигает надпись RECORD. Когда METRUM начнет записывать, индикатор и надпись будут гореть постоянно. Во время записи счет блоков будет также увеличиваться.	2.4.6		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons. (Note: The *OVERRANGE CHECKING* and *OVERRANGE HOLD* softkeys should be lit. If they are not, press them.) (Note: Red light will blink and *RECORD* message will flash in upper right corner of screen for a few seconds while the *METRUM* gets ready to record. Light and message will become steady when the *METRUM* is actually recording. Block count will also increase while recording.)
Записать данные в течение (2) минут после стабилизации (прекращения мигания) индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания. На справочном листке технических данных следует указать давления и температура в кабине.	2.4.7		Record data for two (2) minutes after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet. Record cabin pressure and temperature on data sheet.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK B (Box 104).	2.4.8		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK B* (*BOX* 104).

Наземные измерения (Режим испытаний #G1) (Самолет на стоянке, Двигатели на холостом ходу, СКВ включена)	**2.4**		**Ground Measurements (Test Condition #G1) (Stationary Aircraft, Engines Idling, ECS On)**
Описание	**Этап**	√	**Description**
В справочном листке технических данных следует указать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер стартового (=начального) блока.	2.4.9		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Выполнить операции для автоматического переключения диапазона от пункта 2.4.5.1 до пункта 2.4.5.9.	2.4.10		Perform again the autorange procedures described in steps 2.4.5.1 through 2.4.5.9.
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать кнопку RECORD и удержать ее. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	2.4.11		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.
Записать данные в течение двух (2) минут после прекращения мигания индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания.	2.4.12		Record data for two (2) minutes after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet.
Сообщить экипажу в кабине о готовности к переходу на следующий режим.	2.4.13		Inform cockpit ready for next condition.

Наземные измерения (Режим испытаний #G2) (Самолет на стоянке, Двигатели на холостом ходу, СКВ отключена)	**2.5**		**Ground Measurements (Test Condition #G2) (Stationary Aircraft, Engines Idling, ECS Off)**
Описание	**Этап**	√	**Description**
Проверить, что СКВ (система кондиционирования воздуха) отключена.	2.5.1		Verify that ECS (Environmental Control System = air conditioning) is off.
Если в верхнем правом углу экрана METRUM все еще появляется слово READY, перейти к следующей операции. Если нет, то следует нажать кнопку SPEED в секции TRANSPORT, а затем клавишу ENABLE REC-READY. До перехода к следующей операции подождать, пока в верхнем правом углу экрана появится слово READY.	2.5.2		If *READY* message still appears in upper right corner of *METRUM* screen, proceed to next step. Otherwise, press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	2.5.3		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На справочном листке технических данных записать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока.	2.5.4		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Для автоматического переключения диапазона измерений уровня входящего сигнала на METRUM проделать следующие операции:	2.5.5		Perform the following procedures to autorange the input level on the *METRUM* :
Нажать кнопку BAR в секции DISPLAY;	2.5.5.1		Press *BAR* button in *DISPLAY* section.
Нажать клавишу AUTORANGE SOFTKEYS (после нажатия клавиша должна загораться).	2.5.5.2		Press *AUTORANGE SOFTKEYS* softkey (softkey should be lit after pressing).
Нажать клавишу ENABLE AUTORANGE и подождать пока погаснет освещение клавиши ENABLE AUTORANGE.	2.5.5.3		Press *ENABLE AUTORANGE* softkey and wait until *ENABLE AUTORANGE* softkey light turns itself off.
Нажать клавишу AUTORANGE MODE (после нажатия клавиша должна загореться).	2.5.5.4		Press *AUTORANGE MODE* softkey (softkey should be lit after pressing).

Наземные измерения (Режим испытаний #G2) (Самолет на стоянке, Двигатели на холостом ходу, СКВ отключена)	**2.5**		**Ground Measurements (Test Condition #G2) (Stationary Aircraft, Engines Idling, ECS Off)**
Описание	**Этап**	√	**Description**
Нажать кнопку INCR в секции VALUE ENTRY для переключения в режим автоматического переключения диапазона измерений -CONTINUOUS.	2.5.5.5		Press *INCR* button in *VALUE ENTRY* section to switch to *CONTINUOUS* autorange mode.
Нажать клавишу ENABLE AUTORANGE (клавиша должна загореться после нажатия) и подождать 10 секунд.	2.5.5.6		Press *ENABLE AUTORANGE* softkey (softkey should be lit after pressing) and wait 10 seconds.
Для отмены команды нажать клавишу ENABLE AUTORANGE еще раз. После нажатия клавиша должна погаснуть.	2.5.5.7		Press *ENABLE AUTORANGE* softkey again to disable. Softkey should be unlit after pressing.
Нажать кнопку DECR в секции VALUE ENTRY для переключения в режим BRIEF - автоматического переключения диапазона измерений.	2.5.5.8		Press *DECR* button in *VALUE ENTRY* section to switch to *BRIEF* autorange mode.
Нажать клавишу AUTORANGE SOFTKEYS для выхода из режима автоматического переключения диапазона измерений (после нажатия клавиша должна погаснуть).	2.5.5.9		Press *AUTORANGE SOFTKEYS* softkey to exit autorange function (softkey should be unlit after pressing).
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать и удерживать кнопку RECORD. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	2.5.6		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.

Наземные измерения (Режим испытаний #G2) (Самолет на стоянке, Двигатели на холостом ходу, СКВ отключена)	**2.5**		**Ground Measurements (Test Condition #G2) (Stationary Aircraft, Engines Idling, ECS Off)**
Описание	**Этап**	√	**Description**
Записать данные в течение (2) минут после стабилизации (прекращения мигания) индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания. На справочном листке технических данных следует указать давления и температура в кабине.	2.5.7		Record data for two (2) minutes after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet. Record cabin pressure and temperature on data sheet.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK B (Box 104).	2.5.8		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK B* (*BOX* 104).
В справочном листке технических данных следует указать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер стартового блока.	2.5.9		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Выполнить операции для автоматического переключения диапазона от пункта 2.5.5.1 до пункта 2.5.5.9.	2.5.10		Perform again the autorange procedures described in steps 2.5.5.1 through 2.5.5.9.
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать кнопку RECORD и удержать ее. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	2.5.11		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.

Наземные измерения (Режим испытаний #G2) (Самолет на стоянке, Двигатели на холостом ходу, СКВ отключена)	**2.5**		**Ground Measurements (Test Condition #G2) (Stationary Aircraft, Engines Idling, ECS Off)**
Описание	**Этап**	√	**Description**
Записать данные в течение двух (2) минут после прекращения мигания индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания.	2.5.12		Record data for two (2) minutes after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet.
Сообщить экипажу в кабине о готовности к переходу на следующий режим.	2.5.13		Inform cockpit ready for next condition.

Наземные измерения (Режим испытаний G3-G6) (Самолет на стоянке, Двигатели работают, СКВ отключена)	**2.6**		**Ground Measurements (Test Conditions G3-G6) (Stationary Aircraft, Engines Running, ECS Off)**
Описание	**Этап**	√	**Description**
Проверить, что СКВ (система кондиционирования воздуха) отключена. Произвести операции от 2.6.2 до 2.6.13 для каждого режима, перечисленного ниже:	2.6.1		Verify that ECS (Environmental Control System = air conditioning) is off. Perform steps 2.6.2 through 2.6.13 for each condition indicated below:

Режим испытания	--	**Двигатели работают в холостом состоянии**			**Test Condition**	**Engines, Thrust Lever Position**	**Engines Idling**
G3	3, 72%	1,2,4			G3	3, 72%	1,2,4
G4	3, 98%	1,2,4			G4	3, 98%	1,2,4
G5	4, 72%	1,2,3			G5	4, 72%	1,2,3
G6	4, 98%	1,2,3			G6	4, 98%	1,2,3

Наземные измерения (Режим испытаний G3-G6) (Самолет на стоянке, Двигатели работают, СКВ отключена)	**2.6**		**Ground Measurements (Test Conditions G3-G6) (Stationary Aircraft, Engines Running, ECS Off)**
Описание	**Этап**	√	**Description**
Перейти к следующей операции, если в правом верхнем углу экрана METRUM появится слово READY. В противном случае нажать кнопку SPEED в секции TRANSPORT, а затем клавишу ENABLE REC-READY. До перехода к следующей операции подождать, пока в верхнем правом углу экрана появится слово READY.	2.6.2		If *READY* message still appears in upper right corner of *METRUM* screen, proceed to next step. Otherwise, press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	2.6.3		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На справочном листке технических данных записать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока.	2.6.4		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Для автоматического переключения диапазона измерений уровня входящего сигнала на METRUM проделать следующие операции:	2.6.5		Perform the following procedures to autorange the input level on the *METRUM* :
Нажать кнопку BAR в секции DISPLAY;	2.6.5.1		Press *BAR* button in *DISPLAY* section.
Нажать клавишу AUTORANGE SOFTKEYS (после нажатия клавиша должна загораться).	2.6.5.2		Press *AUTORANGE SOFTKEYS* softkey (softkey should be lit after pressing).
Нажать клавишу ENABLE AUTORANGE и подождать пока погаснет освещение клавиши ENABLE AUTORANGE.	2.6.5.3		Press *ENABLE AUTORANGE* softkey and wait until *ENABLE AUTORANGE* softkey light turns itself off.
Нажать клавишу AUTORANGE MODE (после нажатия клавиша должна загореться).	2.6.5.4		Press *AUTORANGE MODE* softkey (softkey should be lit after pressing).
Нажать кнопку INCR в секции VALUE ENTRY для переключения в режим автоматического переключения диапазона измерений -CONTINUOUS.	2.6.5.5		Press *INCR* button in *VALUE ENTRY* section to switch to *CONTINUOUS* autorange mode.

Наземные измерения (Режим испытаний G3-G6) (Самолет на стоянке, Двигатели работают, СКВ отключена)	**2.6**		**Ground Measurements (Test Conditions G3-G6) (Stationary Aircraft, Engines Running, ECS Off)**
Описание	**Этап**	√	**Description**
Нажать клавишу ENABLE AUTORANGE (клавиша должна загореться после нажатия) и подождать 10 секунд.	2.6.5.6		Press *ENABLE AUTORANGE* softkey (softkey should be lit after pressing) and wait 10 seconds.
Для отмены команды нажать клавишу ENABLE AUTORANGE еще раз. После нажатия клавиша должна погаснуть.	2.6.5.7		Press *ENABLE AUTORANGE* softkey again to disable. Softkey should be unlit after pressing.
Нажать кнопку DECR в секции VALUE ENTRY для переключения в режим BRIEF - автоматического переключения диапазона измерений.	2.6.5.8		Press *DECR* button in *VALUE ENTRY* section to switch to *BRIEF* autorange mode.
Нажать клавишу AUTORANGE SOFTKEYS для выхода из режима автоматического переключения диапазона измерений (после нажатия клавиша должна погаснуть).	2.6.5.9		Press *AUTORANGE SOFTKEYS* softkey to exit autorange function (softkey should be unlit after pressing).
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать и удерживать кнопку RECORD. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	2.6.6		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.
Записать данные в течение (1) минуты после стабилизации (прекращения мигания) индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания. На справочном листке технических данных следует указать давления и температура в кабине.	2.6.7		Record data for one (1) minute after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet. Record cabin pressure and temperature on data sheet. Conditions G4 and G6: Wait for condition to be re-established. Available record time with afterburners is only 20 seconds.

Наземные измерения (Режим испытаний G3-G6) (Самолет на стоянке, Двигатели работают, СКВ отключена)	**2.6**		**Ground Measurements (Test Conditions G3-G6) (Stationary Aircraft, Engines Running, ECS Off)**
Описание	**Этап**	√	**Description**
Только после последних наземных измерений: нажать кнопку MEMORY в секции SET UP и использовать CURSOR для выделения установленного названия TU-144 Flight Test. Нажать клавишу SAVE SET UP, затем SAVE. После завершения этих операций клавиша SAVE SET UP возвратится в прежнее положение, поскольку она является крайне левой. Примечание: данное установленное название будет использоваться для испытания при первом взлете самолета.	2.6.7.1		After last ground measurement only: Press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 FLIGHT TEST* setup name. Press *SAVE SETUP* softkey, then *SAVE* softkey. When this action is completed, the *SAVE SETUP* softkey will come back as the left-most softkey. (Note: This setup will be used for first take-off run).
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK B (Box 104).	2.6.8		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK B* (*BOX* 104).
В справочном листке технических данных следует указать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер стартового блока.	2.6.9		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Выполнить операции для автоматического переключения диапазона от пункта 2.6.5.1 до пумкта 2.6.5.9.	2.6.10		Perform again the autorange procedures described in steps 2.6.51 through 2.6.5.9.
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать кнопку RECORD и удержать ее. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	2.6.11		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.

Наземные измерения (Режим испытаний G3-G6) (Самолет на стоянке, Двигатели работают, СКВ отключена)	**2.6**		**Ground Measurements (Test Conditions G3-G6) (Stationary Aircraft, Engines Running, ECS Off)**
Описание	**Этап**	√	**Description**
Записать данные в течение одной (1) минуты после прекращения мигания индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания.	2.6.12		Record data for one (1) minute after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet.
Сообщить экипажу в кабине о готовности к переходу на следующий режим успытания. Повторить операции от пункта 2.6.2 до 2.6.12 для режимах испытания 4 и 5.	2.6.13		Inform cockpit ready for next condition. Repeat steps 2.6.2 through 2.6.12 for test conditions 4 and 5.

Подготовка к взлету	**2.7**		**Prepare for Take-Off**
Описание	**Этап**	√	**Description**
Нажать кнопку MEMORY в секции SET UP и при помощи курсора выделить установленное название TU-144 FLIGHT TEST. Нажать клавишу RECALL SETUP и затем клавишу RECALL.	2.7.1		Press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 FLIGHT TEST* setup name. Press *RECALL SETUP* softkey, then *RECALL* softkey.
Вставить новую ленту, нажать кнопку SPEED в секции TRANSPORT, а затем клавишу ENABLE REC READY. До перехода к другим операциям подождать пока в верхнем правом углу экрана появится слово READY.	2.7.2		Insert a new tape, then press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
При подготовке к взлету закрыть ящики этажерки и закрепить ключи.	2.7.3		Secure instrument pallet drawers and keys in preparation for take-off.

Подготовка к взлету	**2.7**		**Prepare for Take-Off**
Описание	**Этап**	√	**Description**
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	2.7.4		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На новом справочном листке технических данных записать название кассеты, число, номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока.	2.7.5		On a new data sheet, record cassette name and date, run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number.
Американские специалисты выходят из самолета	2.7.6		US Team exits aircraft

Наземные измерения (Режим испытаний G7) (Самолет на стоянке, Двигатели работают, СКВ включена)	**3.0**		**Ground Measurements (Test Condition G7) (Stationary Aircraft, Engines Running, ECS On)**
Описание	**Этап**	√	**Description**
Проверить, что СКВ (система кондиционирования воздуха) работает на полную мощность. Все четыре (4) двигателя работают на близко к тяге взлета.	3.0.1		Verify that ECS (Environmental Control System = air conditioning) is running at full load. All four (4) engines at close to takeoff thrust.
Перейти к следующей операции, если в правом верхнем углу экрана METRUM появится слово READY. В противном случае нажать кнопку SPEED в секции TRANSPORT, а затем клавишу ENABLE REC-READY. До перехода к следующей операции подождать, пока в верхнем правом углу экрана появится слово READY.	3.0.2		If *READY* message still appears in upper right corner of *METRUM* screen, proceed to next step. Otherwise, press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	3.0.3		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На справочном листке технических данных записать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока.	3.0.4		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Для автоматического переключения диапазона измерений уровня входящего сигнала на METRUM проделать следующие операции:	3.0.5		Perform the following procedures to autorange the input level on the *METRUM* :
Нажать кнопку BAR в секции DISPLAY;	3.0.5.1		Press *BAR* button in *DISPLAY* section.
Нажать клавишу AUTORANGE SOFTKEYS (после нажатия клавиша должна загораться).	3.0.5.2		Press *AUTORANGE SOFTKEYS* softkey (softkey should be lit after pressing).
Нажать клавишу ENABLE AUTORANGE и подождать пока погаснет освещение клавиши ENABLE AUTORANGE.	3.0.5.3		Press *ENABLE AUTORANGE* softkey and wait until *ENABLE AUTORANGE* softkey light turns itself off.
Нажать клавишу AUTORANGE MODE (после нажатия клавиша должна загореться).	3.0.5.4		Press *AUTORANGE MODE* softkey (softkey should be lit after pressing).

Наземные измерения (Режим испытаний G7) (Самолет на стоянке, Двигатели работают, СКВ включена)	**3.0**		**Ground Measurements (Test Condition G7) (Stationary Aircraft, Engines Running, ECS On)**
Описание	**Этап**	√	**Description**
Нажать кнопку INCR в секции VALUE ENTRY для переключения в режим автоматического переключения диапазона измерений -CONTINUOUS.	3.0.5.5		Press *INCR* button in *VALUE ENTRY* section to switch to *CONTINUOUS* autorange mode.
Нажать клавишу ENABLE AUTORANGE (клавиша должна загореться после нажатия) и подождать 10 секунд.	3.0.5.6		Press *ENABLE AUTORANGE* softkey (softkey should be lit after pressing) and wait 10 seconds.
Для отмены команды нажать клавишу ENABLE AUTORANGE еще раз. После нажатия клавиша должна погаснуть.	3.0.5.7		Press *ENABLE AUTORANGE* softkey again to disable. Softkey should be unlit after pressing.
Нажать кнопку DECR в секции VALUE ENTRY для переключения в режим BRIEF - автоматического переключения диапазона измерений.	3.0.5.8		Press *DECR* button in *VALUE ENTRY* section to switch to *BRIEF* autorange mode.
Нажать клавишу AUTORANGE SOFTKEYS для выхода из режима автоматического переключения диапазона измерений (после нажатия клавиша должна погаснуть).	3.0.5.9		Press *AUTORANGE SOFTKEYS* softkey to exit autorange function (softkey should be unlit after pressing).
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать и удерживать кнопку RECORD. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	3.0.6		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.

Наземные измерения (Режим испытаний G7) (Самолет на стоянке, Двигатели работают, СКВ включена)	**3.0**		**Ground Measurements (Test Condition G7) (Stationary Aircraft, Engines Running, ECS On)**
Описание	**Этап**	√	**Description**
Записать данные в течение (1) минуты после стабилизации (прекращения мигания) индикатора и нажать STOP. Во время записи голосом следует добавить соответствующие комментарии. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания. На справочном листке технических данных следует указать давления и температура в кабине.	3.0.7		Record data for one (1) minute after the light has become steady, then press *STOP*. While recording, provide relevant voice annotation. Record end block number, condition of overrange indicator and any comments on data sheet. Record cabin pressure and temperature on data sheet.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	3.0.8		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).

Замеры при взлете (Режим испытаний #7)	**3.1**		**Measurements During Take-Off (Test Condition #7)**
Описание	**Этап**	√	**Description**
Отменяется	3.1.1 - 3.1.5		DELETED
В справочном листке технических данных следует указать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер стартового блока.	3.1.6.1		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Сообщить экипажу в кабине о готовности к взлету.	3.1.6.2		Inform cockpit ready for take-off.
Непосредственно перед предполетной выкаткой нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать и удержать кнопку RECORD. Удерживая кнопку RECORD, нажать PLAY, затем отпустить обе кнопки.	3.1.7		Just before take-off roll, press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.

Замеры при взлете (Режим испытаний #7)	3.1		Measurements During Take-Off (Test Condition #7)
Описание	**Этап**	√	**Description**
После покидания кресла после взлета (высота 500 м, если не указано иное), нажать STOP. В справочном листке технических данных следует указать номер стартового блока, показания индикатора выхода за пределы диапазона и любые другие замечания.	3.1.8		After takeoff (altitude 500m, unless otherwise directed), press *STOP*. Record end block number, condition of overrange indicator, and any comments on data sheet.

Измерения в полете.	3.2		Flight Measurements
Описание	**Этап**	√	**Description**
Произвести следующие операции (3.2.2 до 3.2.15) для каждого режима полета.	3.2.1		Perform the following steps (3.2.2 through 3.2.15) for each flight condition.
Перейти к следующей операции, если в правом верхнем углу экрана METRUM появится слово READY. В противном случае нажать кнопку SPEED в секции TRANSPORT, а затем клавишу ENABLE REC-READY. До перехода к следующей операции подождать, пока в верхнем правом углу экрана появится слово READY.	3.2.2		If *READY* message still appears in upper right corner of *METRUM* screen, proceed to next step. Otherwise, press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	3.2.3		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На справочном листке технических данных записать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока.	3.2.4		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
После достижение нужного режима испитания для автоматического переключения диапазона измерений уровня входящего сигнала на METRUM проделать следующие операции:	3.2.5		When the desired stable test condition has been reached, perform the following procedures to autorange the input level on the *METRUM* :
Нажать кнопку BAR в секции DISPLAY;	3.2.5.1		Press *BAR* button in *DISPLAY* section.

Измерения в полете.	**3.2**		**Flight Measurements**
Описание	**Этап**	√	**Description**
Нажать клавишу AUTORANGE SOFTKEYS (после нажатия клавиша должна загораться).	3.2.5.2		Press *AUTORANGE SOFTKEYS* softkey (softkey should be lit after pressing).
Нажать клавишу ENABLE AUTORANGE и подождать пока погаснет освещение клавиши ENABLE AUTORANGE.	3.2.5.3		Press *ENABLE AUTORANGE* softkey and wait until *ENABLE AUTORANGE* softkey light turns itself off.
Нажать клавишу AUTORANGE MODE (после нажатия клавиша должна загореться).	3.2.5.4		Press *AUTORANGE MODE* softkey (softkey should be lit after pressing).
Нажать кнопку INCR в секции VALUE ENTRY для переключения в режим автоматического переключения диапазона измерений -CONTINUOUS.	3.2.5.5		Press *INCR* button in *VALUE ENTRY* section to switch to *CONTINUOUS* autorange mode.
Нажать клавишу ENABLE AUTORANGE (клавиша должна загореться после нажатия) и подождать 10 секунд.	3.2.5.6		Press *ENABLE AUTORANGE* softkey (softkey should be lit after pressing) and wait 10 seconds.
Для отмены команды нажать клавишу ENABLE AUTORANGE еще раз. После нажатия клавиша должна погаснуть.	3.2.5.7		Press *ENABLE AUTORANGE* softkey again to disable. Softkey should be unlit after pressing.
Нажать кнопку DECR в секции VALUE ENTRY для переключения в режим BRIEF - автоматического переключения диапазона измерений.	3.2.5.8		Press *DECR* button in *VALUE ENTRY* section to switch to *BRIEF* autorange mode.
Нажать клавишу AUTORANGE SOFTKEYS для выхода из режима автоматического переключения диапазона измерений (после нажатия клавиша должна погаснуть).	3.2.5.9		Press *AUTORANGE SOFTKEYS* softkey to exit autorange function (softkey should be unlit after pressing).
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать и удерживать кнопку RECORD. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	3.2.6		Press OVERRANGE CLEAR button in DISPLAY section. Press RECORD and hold. While holding RECORD, press PLAY, then release both buttons.

Измерения в полете.	3.2		Flight Measurements
Описание	**Этап**	√	**Description**
На справочном листке технических данных следует указать число Маха, высоту, и давления и температура в кабине, голосом производятся соответствующие комментарии.	3.2.7		Record mach number, altitude, cabin pressure, and cabin temperature on data sheet. Provide relevant voice annotation.
Записать данные в течение (1) минуты после стабилизации (прекращения мигания) индикатора и нажать STOP. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания.	3.2.8		Record data for one (1) minute after the light has become steady, then press *STOP*. Record end block number, condition of overrange indicator and any comments on data sheet.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK B (Box 104).	3.2.9		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK B* (*BOX* 104).
В справочном листке технических данных следует указать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер стартового блока.	3.2.10		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Выполнить операции для автоматического переключения диапазона от пункта 3.2.5.1 до пункта 3.2.5.9.	3.2.11		Perform again the autorange procedures described in steps 3.2.5.1 through 3.2.5.9.
Нажать кнопку OVERRANGE CLEAR в секции DISPLAY. Нажать кнопку RECORD и удержать ее. Удерживая кнопку RECORD нажать кнопку PLAY, затем отпустить обе кнопки.	3.2.12		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY*, then release both buttons.
На справочном листке технических данных следует указать число Маха, высоту, и давления и температура в кабине, голосом производятся соответствующие комментарии.	3.2.13		Record mach number, altitude, cabin pressure, and cabin temperature on data sheet. Provide relevant voice annotation.

Измерения в полете.	3.2		Flight Measurements
Описание	**Этап**	√	**Description**
Записать данные в течение одной (1) минуты после прекращения мигания индикатора и нажать STOP. На справочном листке технических данных следует записать номер последнего блока, показания индикатора выхода за пределы диапазона и любые другие замечания.	3.2.14		Record data for one (1) minute after the light has become steady, then press *STOP*. Record end block number, condition of overrange indicator and any comments on data sheet.
Сообщить экипажу в кабине о готовности к переходу на следующий режим. Повторить операции 3.2.2 до 3.2.14 для последующих режимов.	3.2.15		Inform cockpit ready for next condition. Repeat steps 3.2.2 through 3.2.14 for next test condition.

Измерения в полете.	**3.2**		**Flight Measurements**
Описание	**Этап**	√	**Description**
Режим готовносеи и записи,запущенный действием в пункте 3.2.2 действует в течении 30 минут. После каждой записи часы вновь на 30 минут. Если время с момента последней записи превысит 25 минут , на экране появится предупреждение " WARNING : Less than 5 minutes remaining for Record Ready"-Предупреждение , осталось менее 5 минут до режима ГОТОВНОСТИ К ЗАПИСИ . В этом сообщении пойдет поминутный отсчет времени до появления надписи "Record Ready disabled , time expired"- состояние готовности к записи прошло , время истекло , а в правом верхнем углу экрана МЕТРУМа появится надпись " STOP "- СТОП . При появлении надписи "Ready"- Готовность в верхнем правом углу экрана МЕТРУМа (даже после появления первой предупреждающей надписи) , часы можно установить вручную на начало отсчета - 30 минут , нажав кнопку "Speed"-Скорость в отделении Transport и , затем , нажав клавишу " Restart time rem "- повторный запуск отсчета времени . Если время истекло и появляется надпись " Stop " - Стоп , заново запустить режим готовности к записи - "Record Ready " согласно операциям , описанным в 3.2.2	3.2.16		Notes: 1) The record ready condition initiated in step 3.2.2 lasts for 30 minutes. The clock is reset to 30 minutes each time a recording is made. If the elapsed time since the last recording exceeds 25 minutes, a warning message will appear on the screen indicating *"Warning: Less than 5 minutes remaining for Record Ready."* This message will countdown each minute until the message *"Record Ready disabled, time expired"* appears and a *STOP* message appears in the upper right corner of the *METRUM* screen. As long as the *READY* message appears in the upper right corner of the *METRUM* screen (even after the first warning message appears), the clock may be manually reset to 30 minutes by pressing the *SPEED* button in the *TRANSPORT* section and then the *RESTART TIME REM.* softkey. If the time has expired and the *STOP* message appears, reinitiate the record ready condition following the procedure in step 3.2.2.

Посадка (высота 1000м до приземления)	**3.3**		**Landing (Altitude 1000m to Touchdown)**
Описание	**Этап**	√	**Description**
Перейти к следующей операции, если в правом верхнем углу экрана METRUM появится слово READY. В противном случае нажать кнопку SPEED в секции TRANSPORT, а затем клавишу ENABLE REC-READY. До перехода к следующей операции подождать, пока в верхнем правом углу экрана появится слово READY.	3.3.1		If *READY* message still appears in upper right corner of *METRUM* screen, proceed to next step. Otherwise, press *SPEED* button in *TRANSPORT* section and then *ENABLE REC-READY* softkey. Wait until a *READY* message appears in upper right corner of screen before proceeding.
Переключить DATA CHANNEL MULTIPLEXER SELECTOR на BANK A (Box 104).	3.3.2		Switch *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK A* (*BOX* 104).
На справочном листке технических данных записать номер испытания, режим испытания, положение DATA CHANNEL MULTIPLEXER SELECTOR и номер начального блока.	3.3.3		Record run number, test condition, *DATA CHANNEL MULTIPLEXER SELECTOR* position and starting block number on data sheet.
Когда нужный режим будет практически достигнут,для автоматического переключения уровня измерений на METRUM проделать следующие процедуры.	3.3.4		When near the desired stable test condition, perform the following procedures to autorange the input level on the *METRUM* :
Нажать кнопку BAR в секции DISPLAY;	3.3.4.1		Press *BAR* button in *DISPLAY* section.
Нажать клавишу AUTORANGE SOFTKEYS (после нажатия клавиша должна загораться).	3.3.4.2		Press *AUTORANGE SOFTKEYS* softkey (softkey should be lit after pressing).
Нажать клавишу ENABLE AUTORANGE и подождать пока погаснет освещение клавиши ENABLE AUTORANGE.	3.3.4.3		Press *ENABLE AUTORANGE* softkey and wait until *ENABLE AUTORANGE* softkey light turns itself off.
Нажать клавишу AUTORANGE MODE (после нажатия клавиша должна загореться).	3.3.4.4		Press *AUTORANGE MODE* softkey (softkey should be lit after pressing).
Нажать кнопку INCR в секции VALUE ENTRY для переключения в режим автоматического переключения диапазона измерений -CONTINUOUS.	3.3.4.5		Press *INCR* button in *VALUE ENTRY* section to switch to *CONTINUOUS* autorange mode.

Посадка (высота 1000м до приземления)	**3.3**		**Landing (Altitude 1000m to Touchdown)**
Описание	**Этап**	√	**Description**
Нажать клавишу ENABLE AUTORANGE (клавиша должна загореться после нажатия) и подождать 10 секунд.	3.3.4.6		Press *ENABLE AUTORANGE* softkey (softkey should be lit after pressing) and wait 10 seconds.
Для отмены команды нажать клавишу ENABLE AUTORANGE еще раз. После нажатия клавиша должна погаснуть.	3.3.4.7		Press *ENABLE AUTORANGE* softkey again to disable. Softkey should be unlit after pressing.
Нажать кнопку DECR в секции VALUE ENTRY для переключения в режим BRIEF - автоматического переключения диапазона измерений.	3.3.4.8		Press *DECR* button in *VALUE ENTRY* section to switch to *BRIEF* autorange mode.
Нажать клавишу AUTORANGE SOFTKEYS для выхода из режима автоматического переключения диапазона измерений (после нажатия клавиша должна погаснуть).	3.3.4.9		Press *AUTORANGE SOFTKEYS* softkey to exit autorange function (softkey should be unlit after pressing).
Нажмите клавишу OVERRANGE CLEAR на дисплее. Нажмите клавишу RECORD и , удерживая ее, нажмите клавишу PLAY и затем отпустите обе клавиши	3.3.5		Press *OVERRANGE CLEAR* button in *DISPLAY* section. Press *RECORD* and hold. While holding *RECORD*, press *PLAY,* then release both buttons.
На справочном листке технических данных следует указать число Махавеличину M, высоту, давления и температура в кабине, голосом производятся соответствующие комментарии.	3.3.6		Record mach number, altitude, cabin pressure, and cabin temperature on data sheet. Provide relevant voice annotation.
После приземления нажмите STOP. Запишите номер последнего блока данных, режим работы индикатора OVERRANGE, а также какие-либо комментарии на листе данных.	3.3.7		After landing press *STOP*. Record end block number, condition of overrange indicator and any comments on data sheet.

Переход на другой источник питания	**3.4**		**Power Transfer**
Описание	**Этап**	√	**Description**
В зависимости от перехода самолета на другой источник питания вазможно перед переходом на другой источник питания потребуется отключить подачу питания к этажерке а затем вновь подать его.	3.4		Depending on aircraft power switch-over procedures, it may be necessary to power down the rack before the switch-over, and power it up again afterwards:
До переключения питания с генератора самолета на ВСУ, экипаж кабины должен сообщить об этом оператору.	3.4.1		Cockpit informs operator prior to switching power from ship's generator to APU.
Непосредственно перед переключением питания с генератора самолета на вспомогательный блок питания (ВСУ): Вытянуть вниз тумблер MASTER POWER в положение OFF(Box 104).	3.4.2		Just before power is switched from ship's generator to APU - Pull out and down on *MASTER POWER* toggle switch to *OFF* position (*BOX* 104).
После переключения питания на ВСУ вытянуть и поставить MASTER POWER в верхнее положение ON, для подачи питания к этажерке КЗА (Box 104).	3.4.3		After power has been switched to APU, pull out and up on *MASTER POWER* toggle switch to *ON* position to power up instrumentation pallet (*BOX* 104).
Проверить подачу питания по трем зеленым индикаторам: один для MASTER POWER, второй для 115V 400Hz, третий для 27V DC(Box 104).	3.4.4		Verify power on with three green lights; one for *MASTER POWER*, one for *115V 400 Hz*, one for *27 VDC* (*BOX* 104).
Убедиться, что работают охлаждающие вентиляторы в верхней части этажерки КЗА.	3.4.5		Verify cooling fans on top of pallet are running.

4. Процедуры после полета.

4. Procedures After Flight

Примечание:	**4.0**		**Note**
Работы по секциям с 4. по 4.2 включительно выполняются американскими специалистами совместно со специалистами АНТК им. А.Н.Туполева.			The work in sections 4. through 4.2, inclusive, will be performed by the US Team with the support of Tupolev personnel.

Послеполетная калибровка микрофонов	**4.1**		**Post-Flight Microphone Calibration**
Описание	**Этап**	√	**Description**
Американские специалисты входят в самолет	4.1.1		US Team boards the aircraft. Possibly more power down-up procedures here!
Снять белый колпачок с предохранителя CB5 (BOX 101) и утапить предохранителя.	4.1.2		Lift white collar on breaker CB5 (Box 101) and push it in.
Установить калибратор на 1kHz и 114dB для следующих калибровок.	4.1.3		Set calibrator on 1 kHz and 114 dB for following calibrations.
Установить DATA CHANNEL MULTIPLEXER SELECTOR на BANK B (Box 104).	4.1.4		Set *DATA CHANNEL MULTIPLEXER SELECTOR* to *BANK B* (*BOX* 104).
Нажать кнопку MEMORY в секции SET UP и использовать CURSOR для выделения установленного названия TU-144 MIC CAL. Нажать клавишу RECALL SET UP, затем RECALL.	4.1.5		Press *MEMORY* button in *SETUP* section and use *CURSOR* to highlight *TU-144 MIC CAL* setup name. Press *RECALL SETUP* softkey, then *RECALL* softkey.
Для каждого из 8 микрофонов записать сигнал калибратора в течение тридцати (30) секунд на магнитофон METRUM. На METRUM отключить все входящие каналы (при помощи меню INPUT CHAN), за исключением калибруемого канала микрофона. Сделать отметку в дневнике калибровки микрофона. Примечание: замерить выход канала на SD-380 и подождать до установки компенсации постоянного тока, перед тем как начать накапливать данные.	4.1.6		Overview: For each of the 8 microphones, record the calibrator signal for thirty (30) seconds on the *METRUM* recorder. Turn off all input channels on *METRUM* (using *INPUT CHAN* menu) except for microphone channel being calibrated. Fill in microphone calibration log sheet. Operation requires two people: calibrator operator (OPC), instrumention rack operator (OPR). Use radio telephones to communicate. (Note: Monitor output channel on SD-380 and wait until DC offset settles out before acquiring data.)

Послеполетная калибровка микрофонов	4.1		Post-Flight Microphone Calibration
Описание	**Этап**	√	**Description**
	4.1.6.1		OPR: Obtain current atmospheric pressure from flight personnel and record on data sheet. Obtain current cabin interior temperature and record on data sheet.
	4.1.6.2		OPC: move to next microphone. OPR: turn off all channels on METRUM except for microphone being calibrated.
	4.1.6.3		OPR: enter Test Name (INPUT CHAN screen)
	4.1.6.4		OPR: connect METRUM output channel to input channel being calibrated (OUTPUT CHAN screen)
	4.1.6.5		OPC: make sure calibrator is OFF. Avoid static electricity discharge. Slip calibrator gently over microphone. Select 1 KHz. Turn ON to 114 dB.
	4.1.6.6		OPR: On METRUM bar display select the channel being calibrated and determine proper range setting.
	4.1.6.7		OPR: On SD-380 watch signal (nice sine wave?). Wait for DC component to die out.
	4.1.6.8		OPR: Write down beginning block number
	4.1.6.9		OPR: Record signal on METRUM for 30 seconds
	4.1.6.10		OPR: Tell OPC to turn calibrator off OPC: Avoid static electricity discharge. Gently remove calibrator from microphone.
.	4.1.6.11		OPR: Write down ending block number and other relevant information

Выключение двигателя.	**4.2**		**Power Down**
Описание	**Этап**	√	**Description**
Для перемотки ленты нажать кнопку REW. По окончании этой операции в верхнем правом углу экрана METRUM появится слово STOP. По окончании операции нажать кнопку EJECT и снять ленту.	4.2.1		Press *REW* button to rewind tape. *STOP* message will appear in upper right corner of *METRUM* screen when this operation is completed. When complete, press *EJECT* and remove tape.
Вытянуть вниз тумблер MASTER POWER в положение OFF(Box 104).	4.2.3		Pull out and down on *MASTER POWER* toggle switch to *OFF* position (*BOX* 104).
Примечание: Немедленно после каждого испытания, и независимо от условий погоды, защищать все датчики (Kulites) на внешней обшивке фюзеляжа, покрывая их лентой после охлаждения обшивки (во избежание плавления лентыS.			Note: Immediately after each test, and irrespective of weather conditions, protect all transducers in the outer fuselage skin by covering them with adhesive tape. (Wait until the skin has cooled enough so that the tape does not melt)

Appendix G Auxiliary Data

The following pages show plots of auxiliary data required for analyzing the main time history boundary layer, structural, and acoustic data.

Temperatures are shown in the plots as received from NASA DFRC FDAS files. It is obvious that some of them are saddled with an offset which has been removed in the average data contained in the MATLAB auxiliary data files.

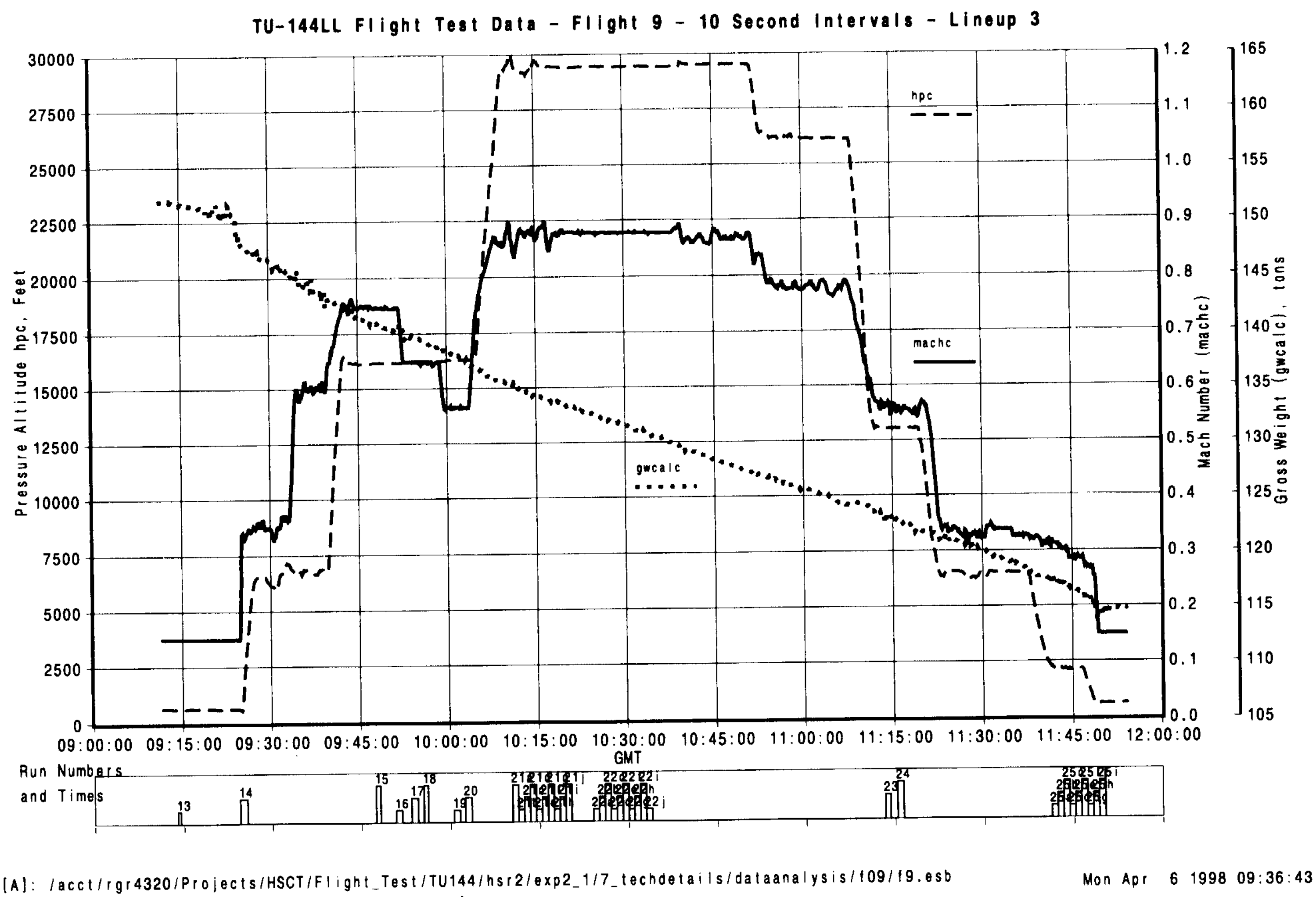


Figure 51: Flight 9 auxiliary data.

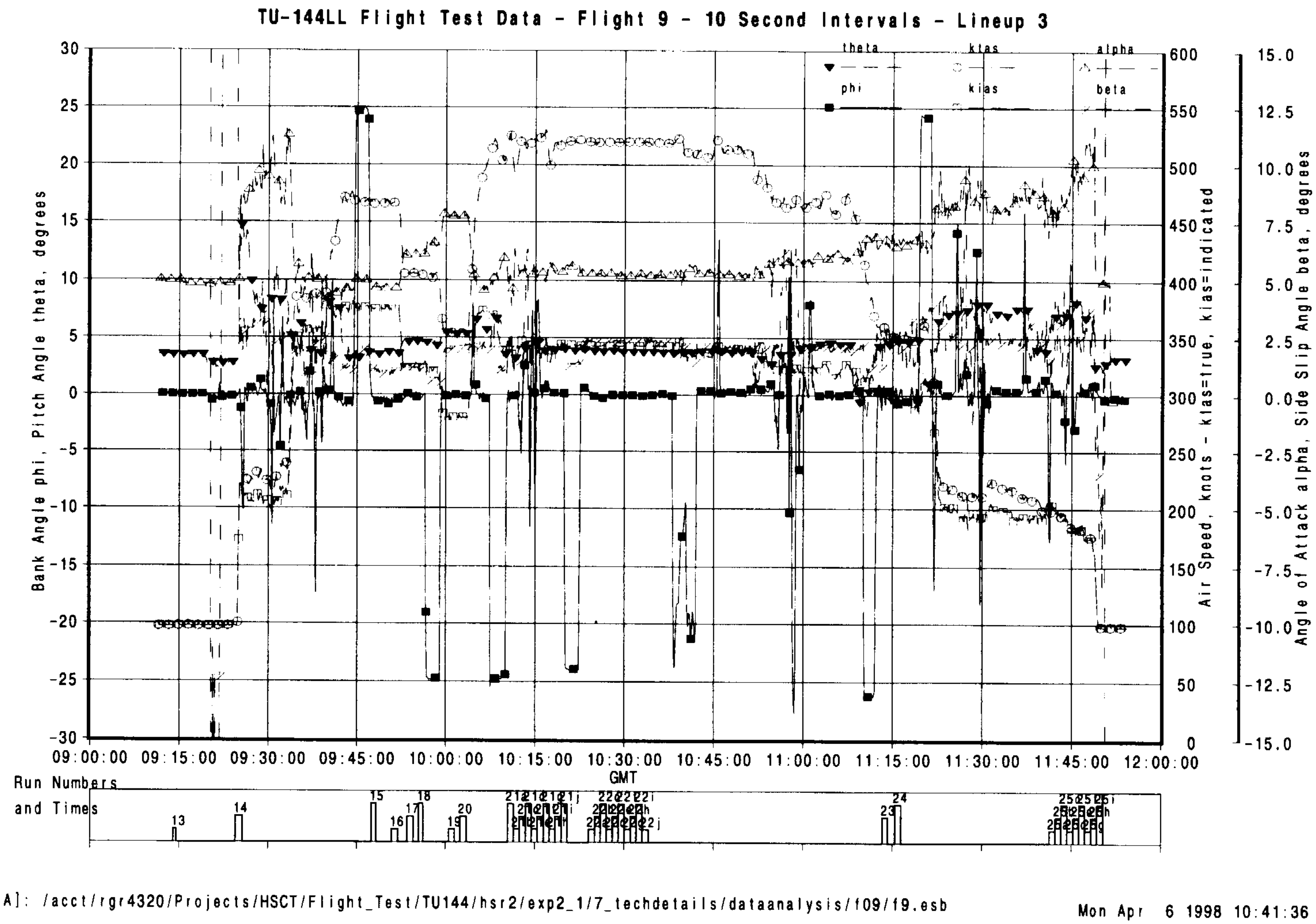


Figure 51 (continued)

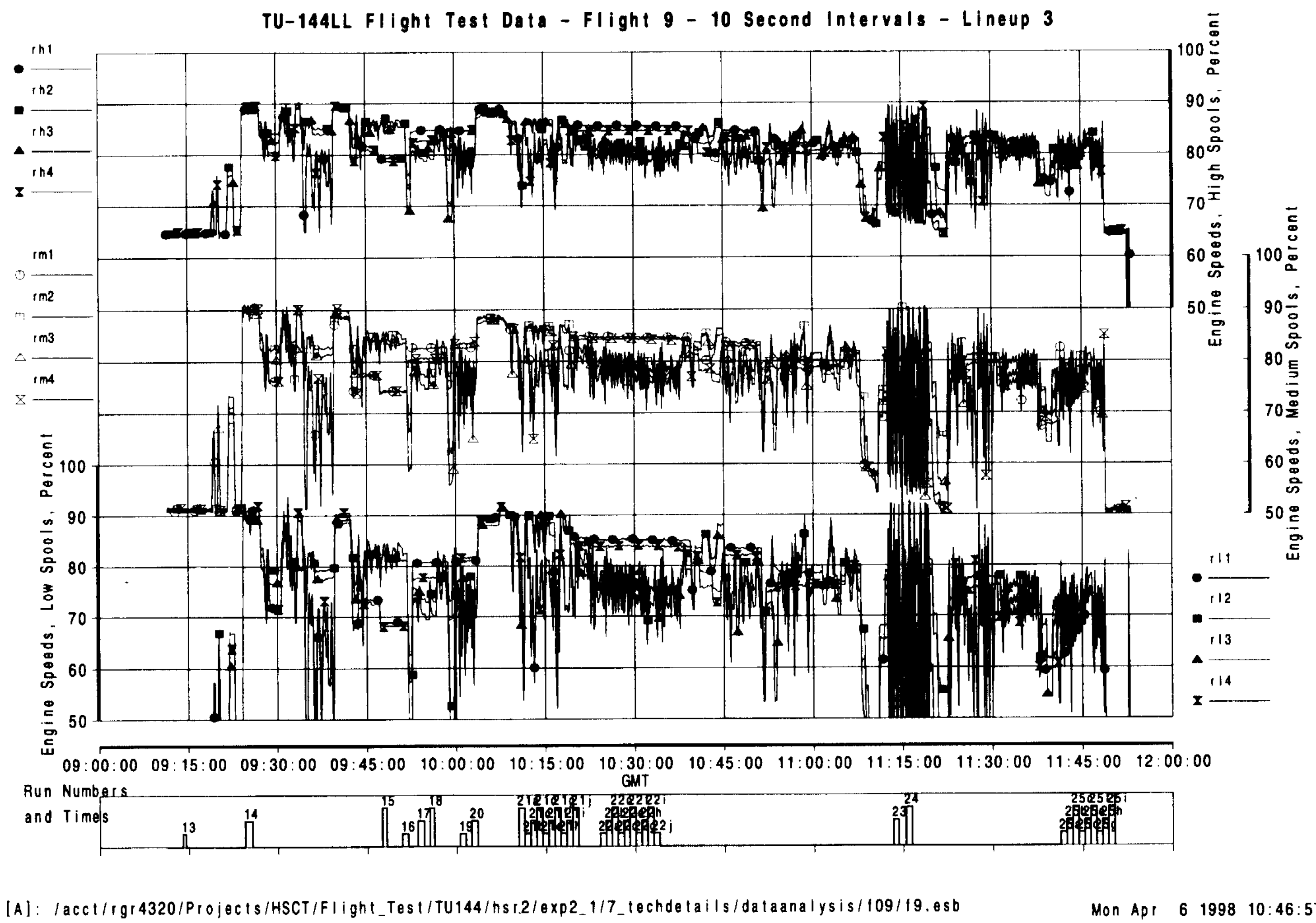


Figure 51 (continued)

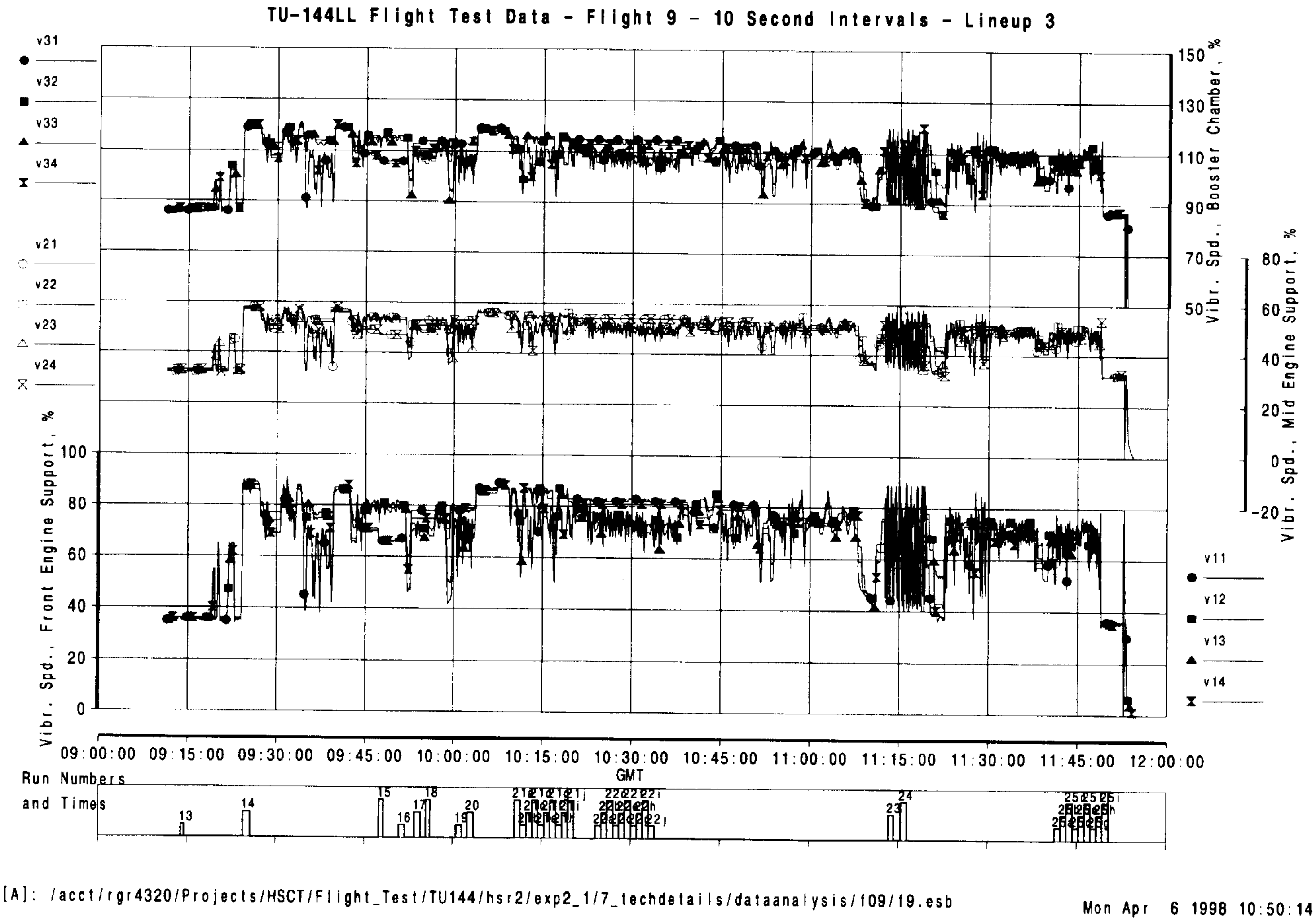


Figure 51 (continued)

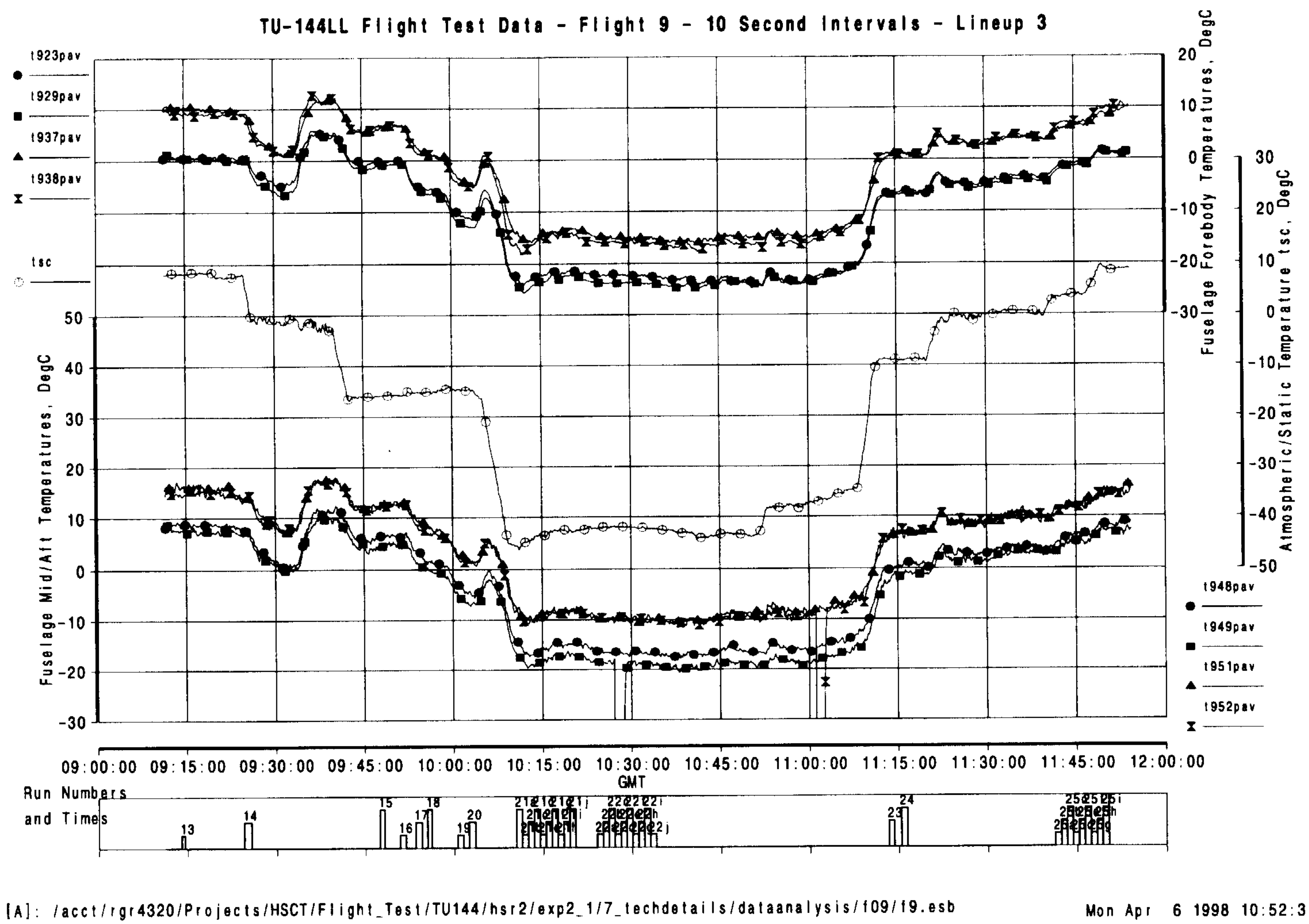
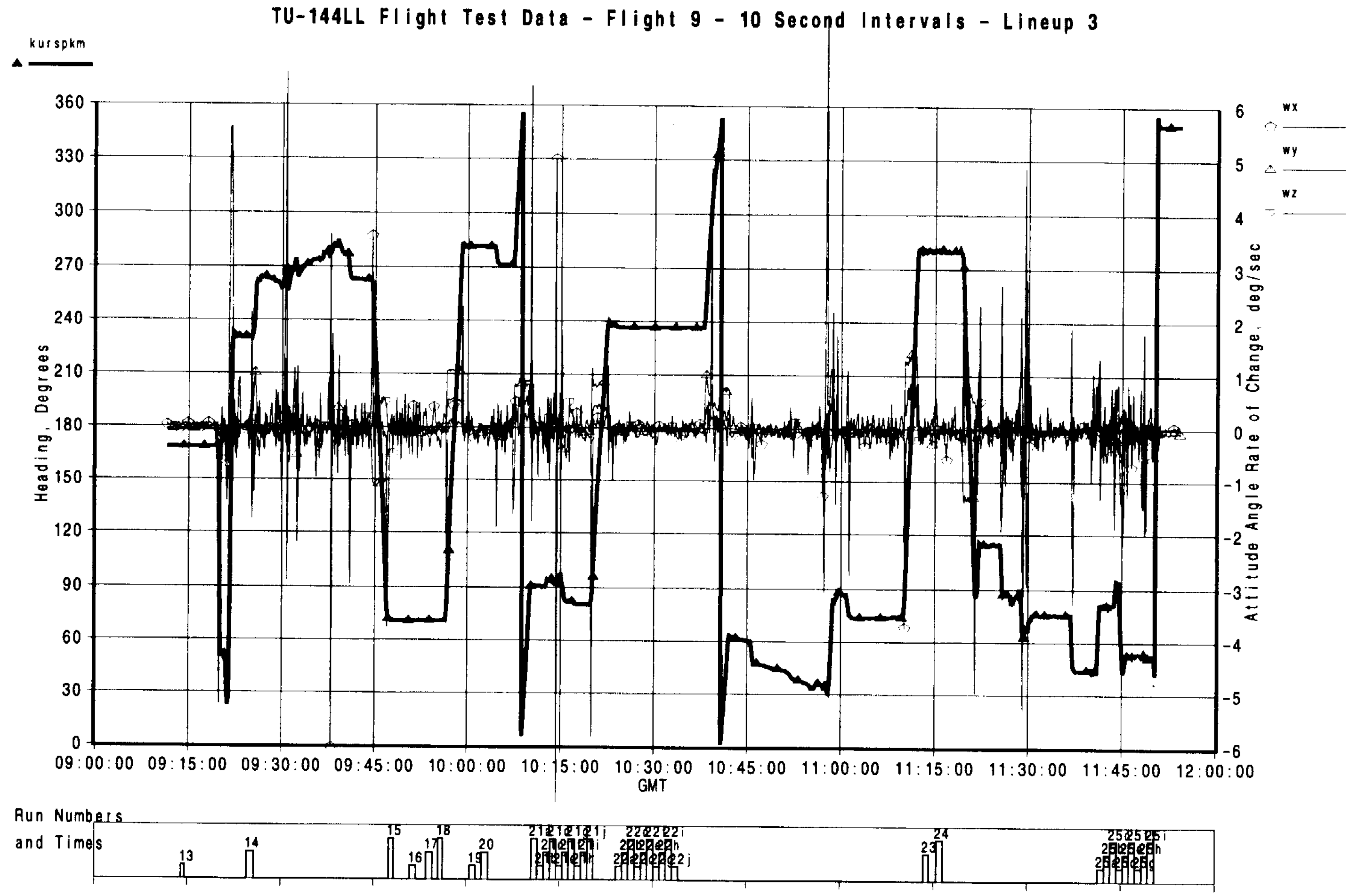


Figure 51 (continued)



[A]: /acct/rgr4320/Projects/HSCT/Flight_Test/TU144/hsr2/exp2_1/7_techdetails/dataanalysis/f09/f9.esb

State File: /acct/rgr4320/Projects/HSCT/Flight_Test/TU144/hsr2/exp2_1/7_techdetails/dataanalysis/f09/f9xy.peg

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Figure 51 (continued)

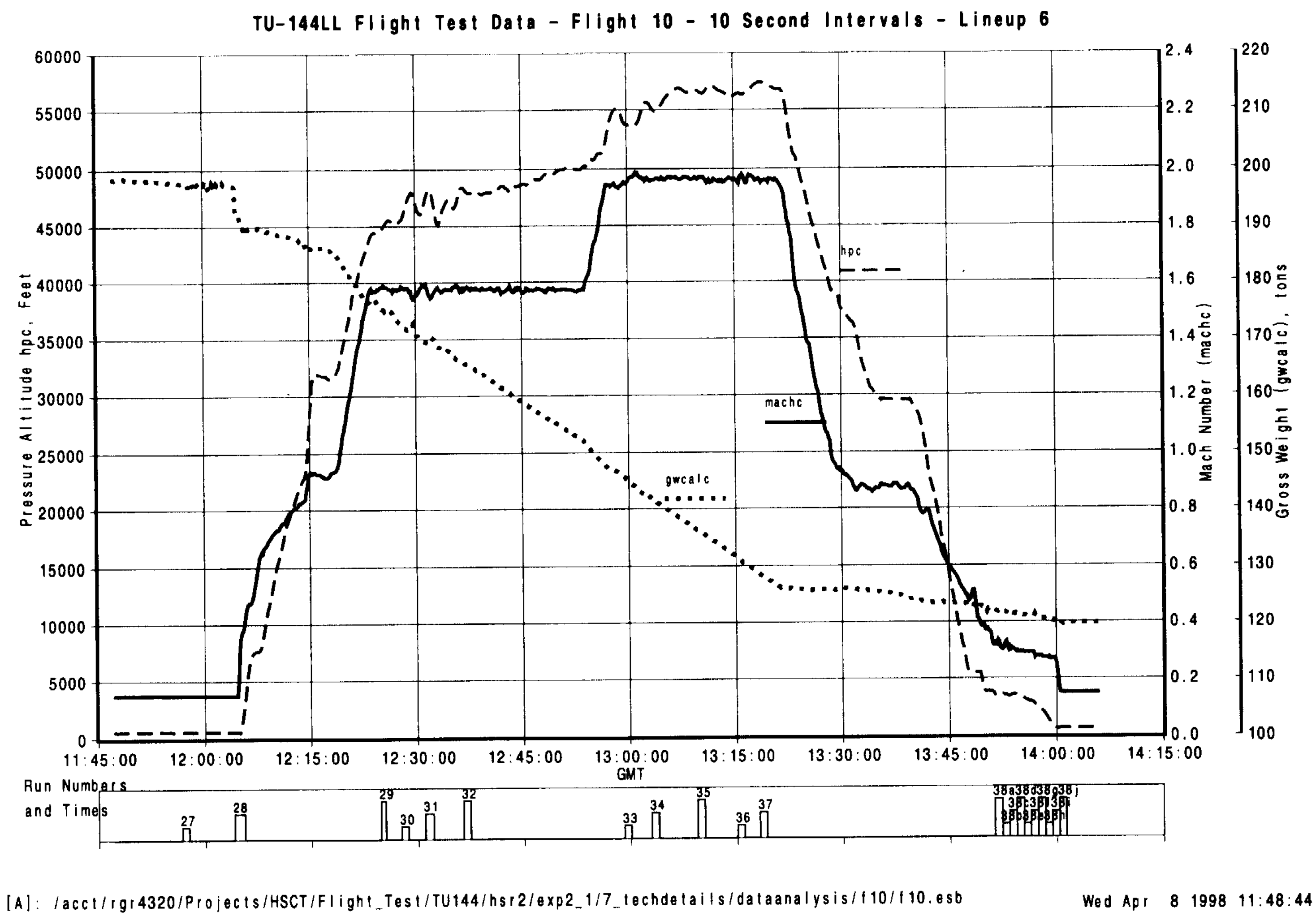


Figure 52: Flight 10 auxiliary data.

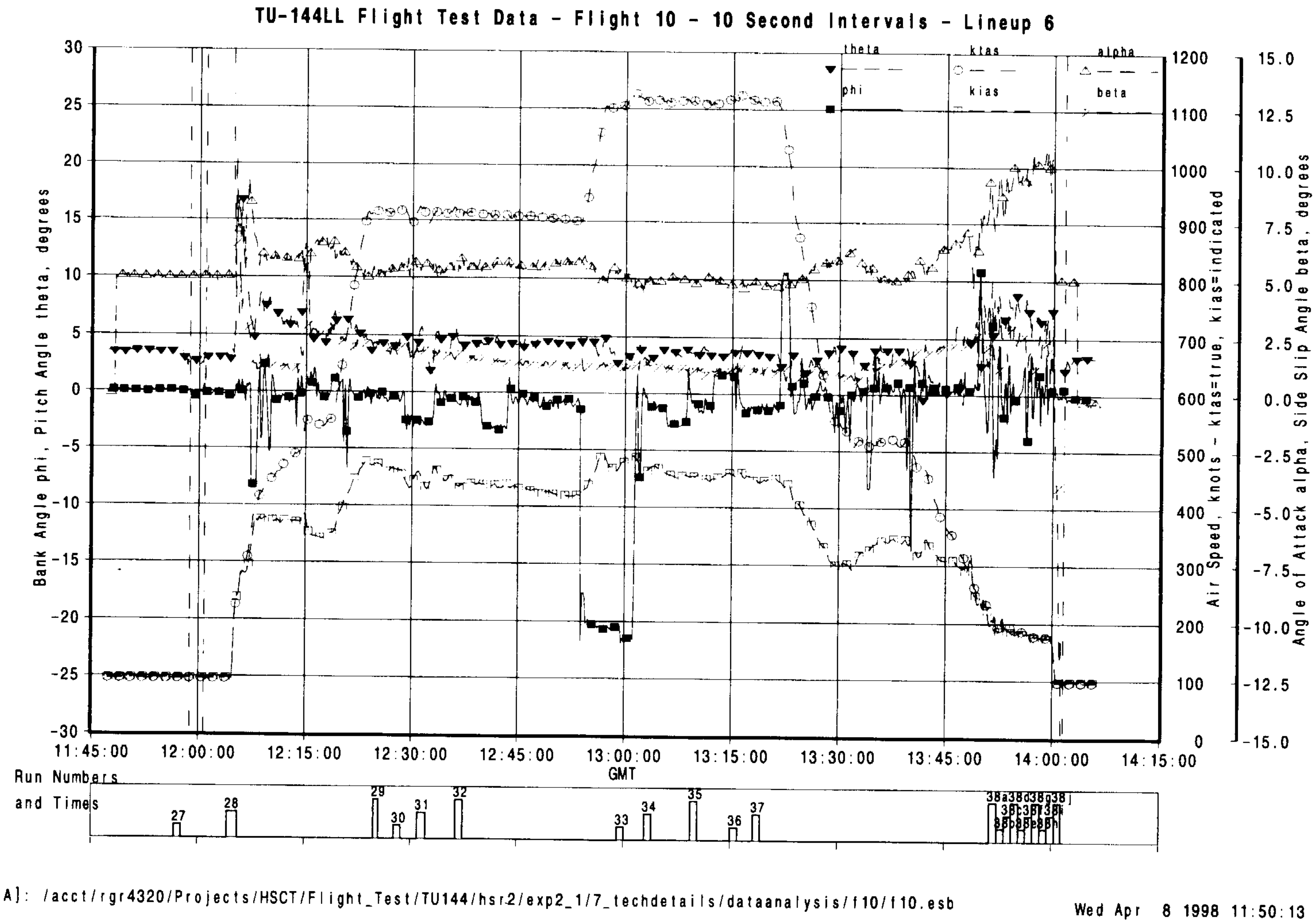


Figure 52 (continued)

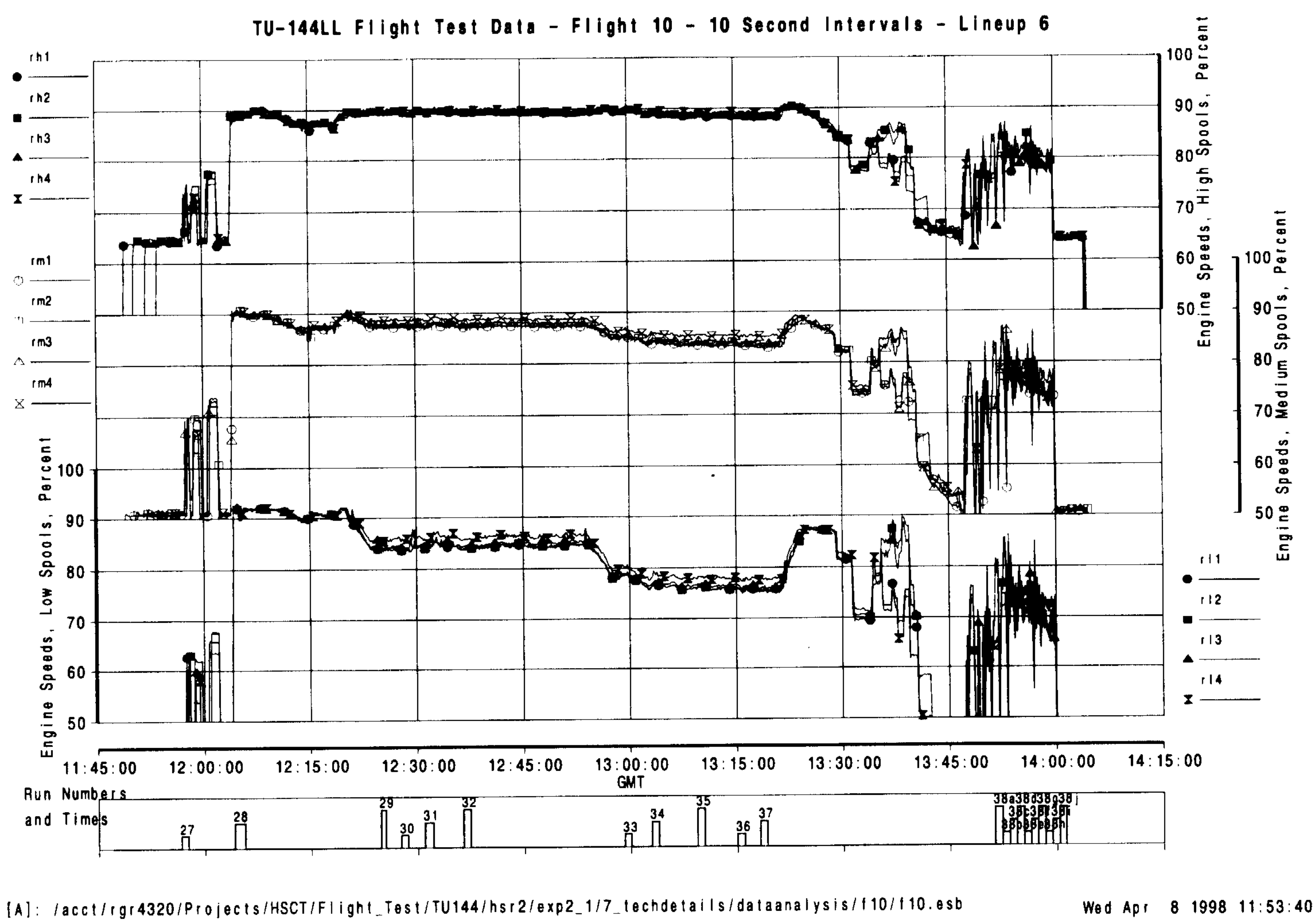


Figure 52 (continued)

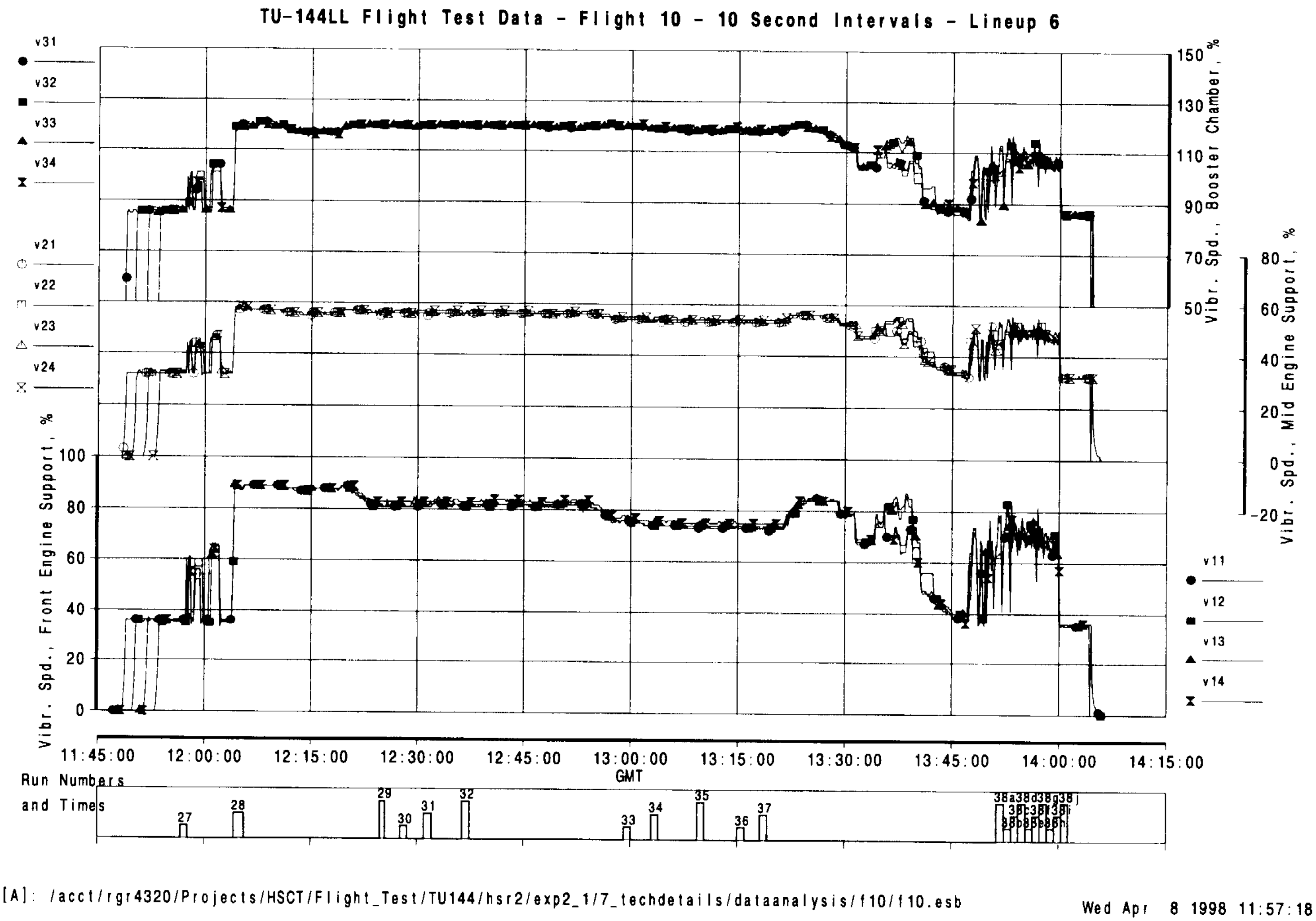


Figure 52 (continued)

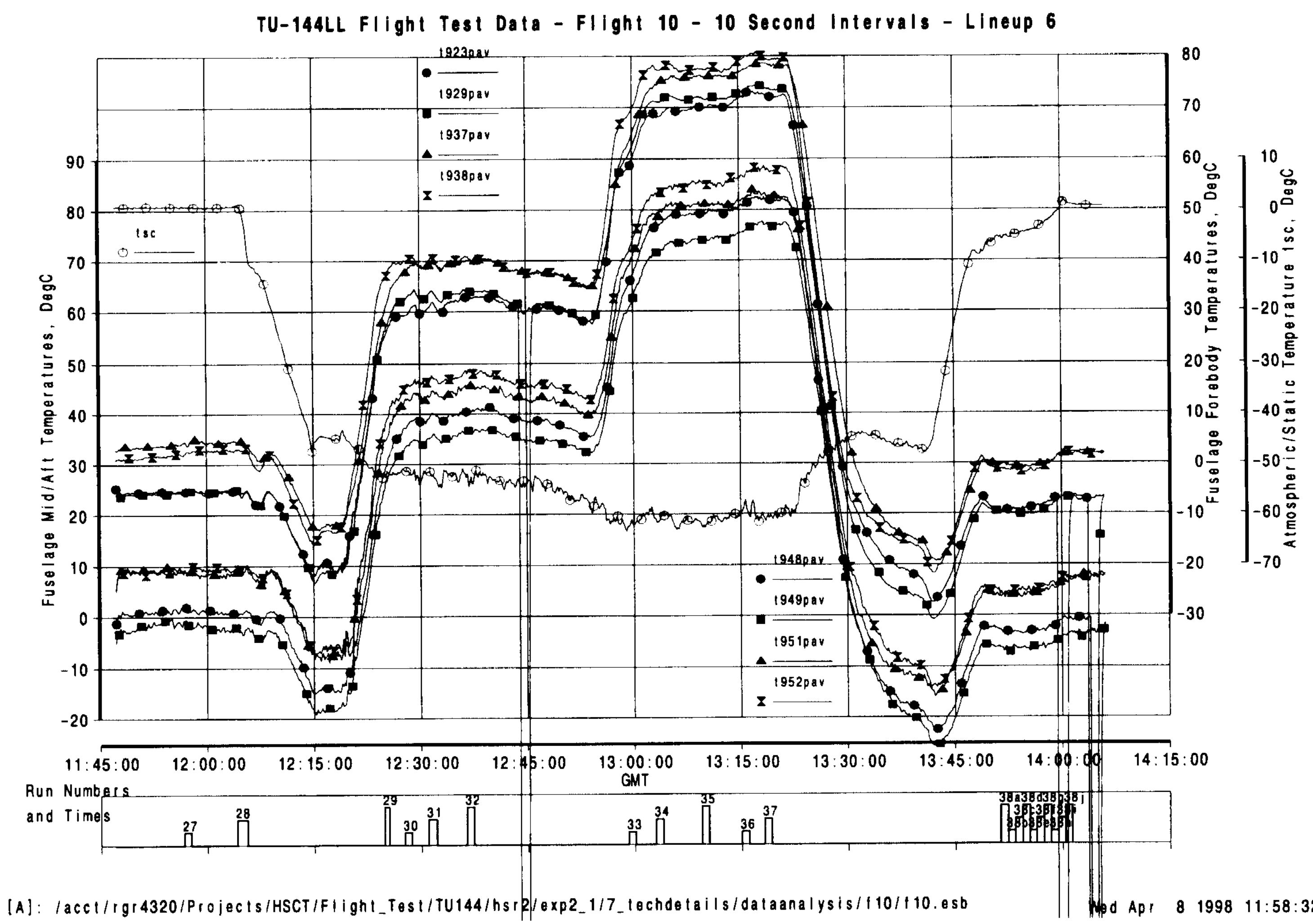


Figure 52 (continued)

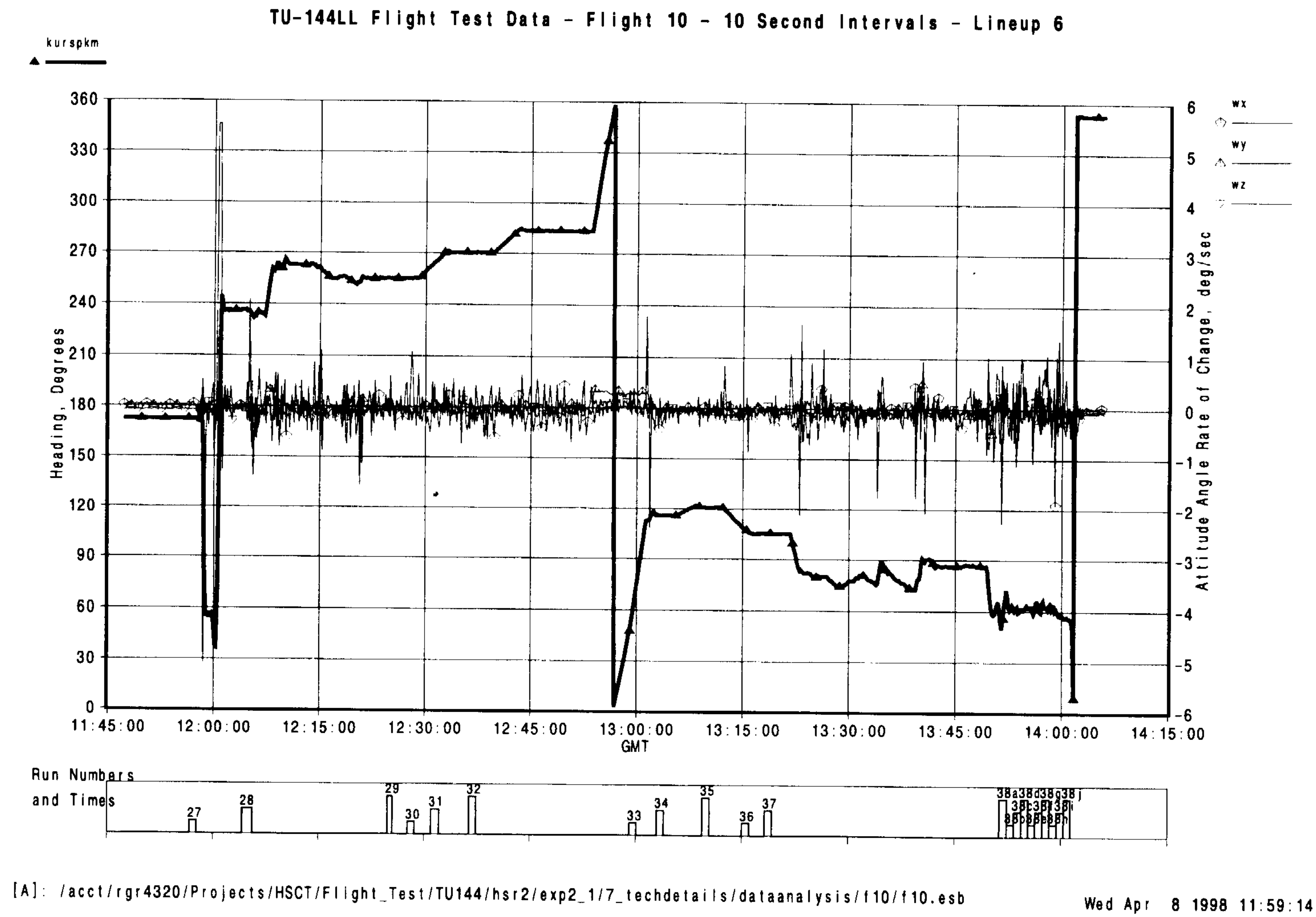


Figure 52 (continued)

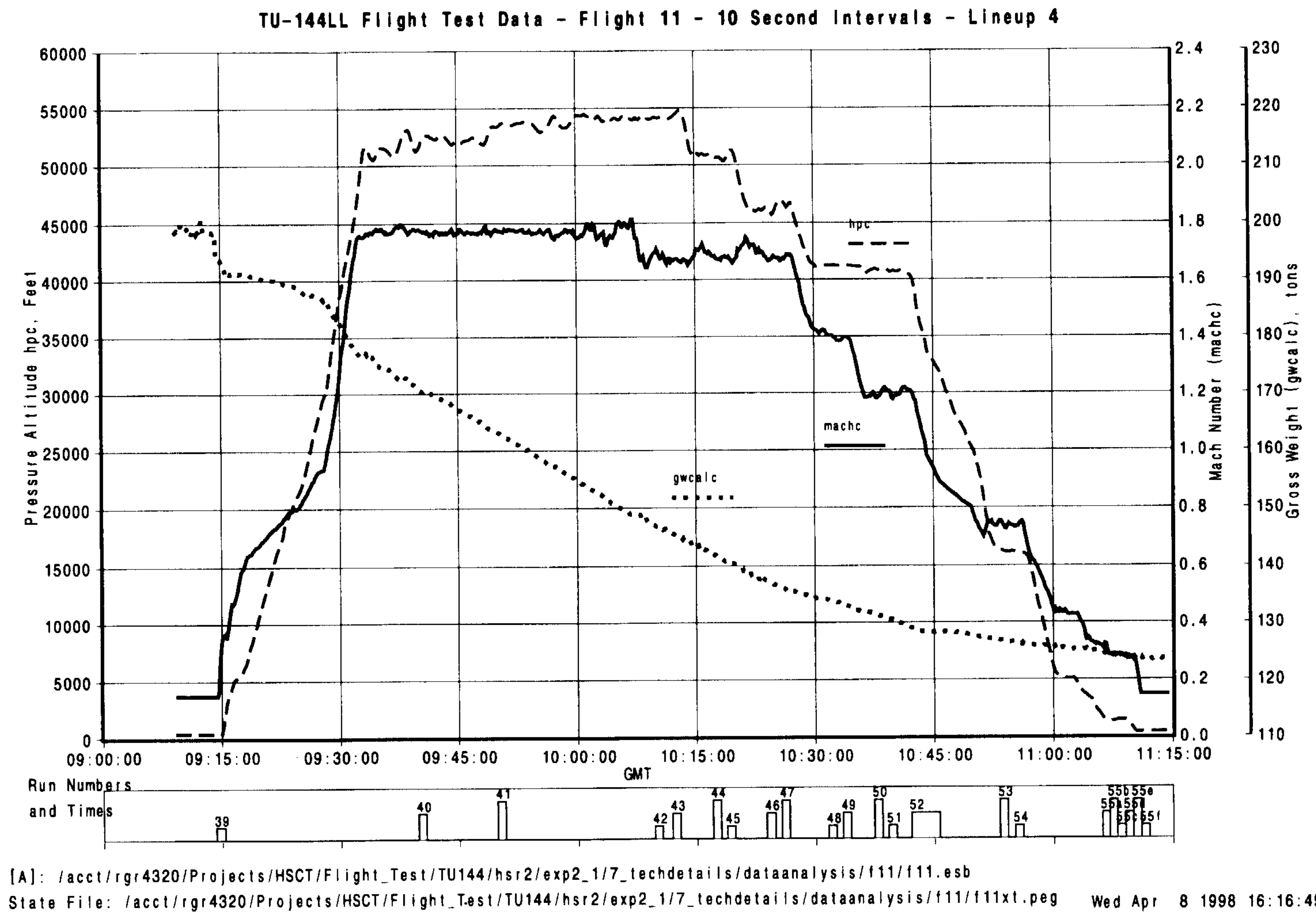


Figure 53: Flight 11 auxiliary data.

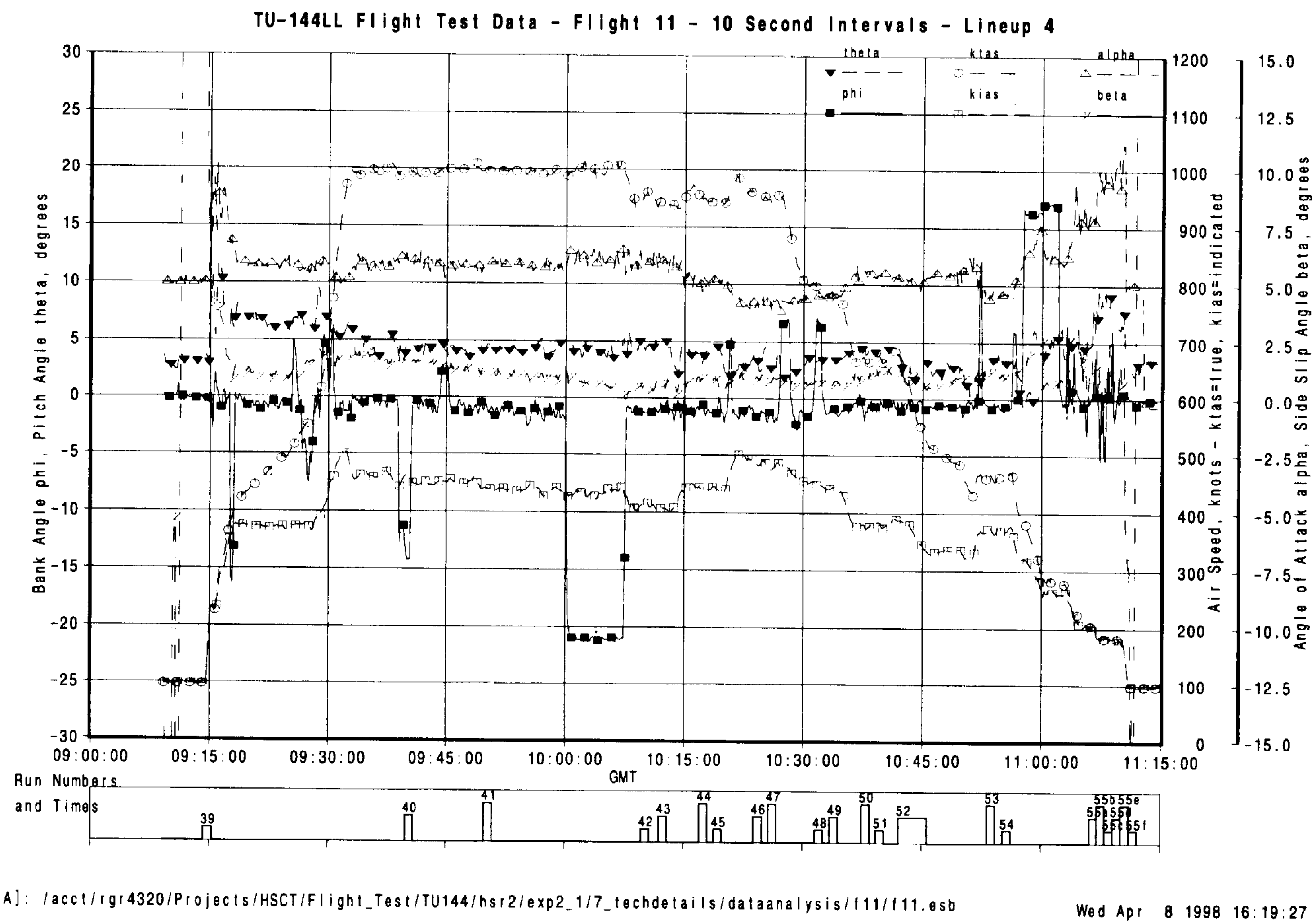


Figure 53 (continued)

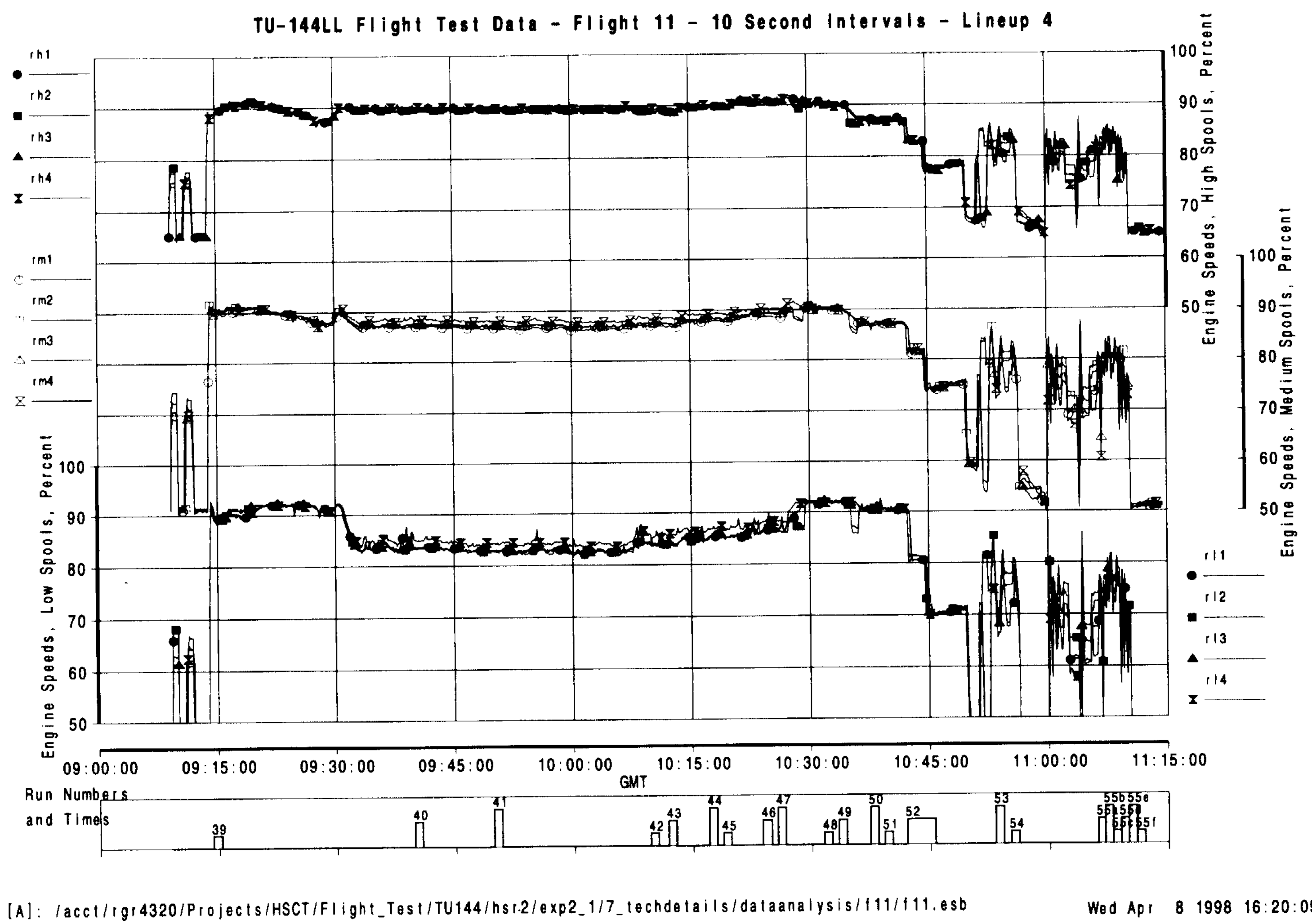


Figure 53 (continued)

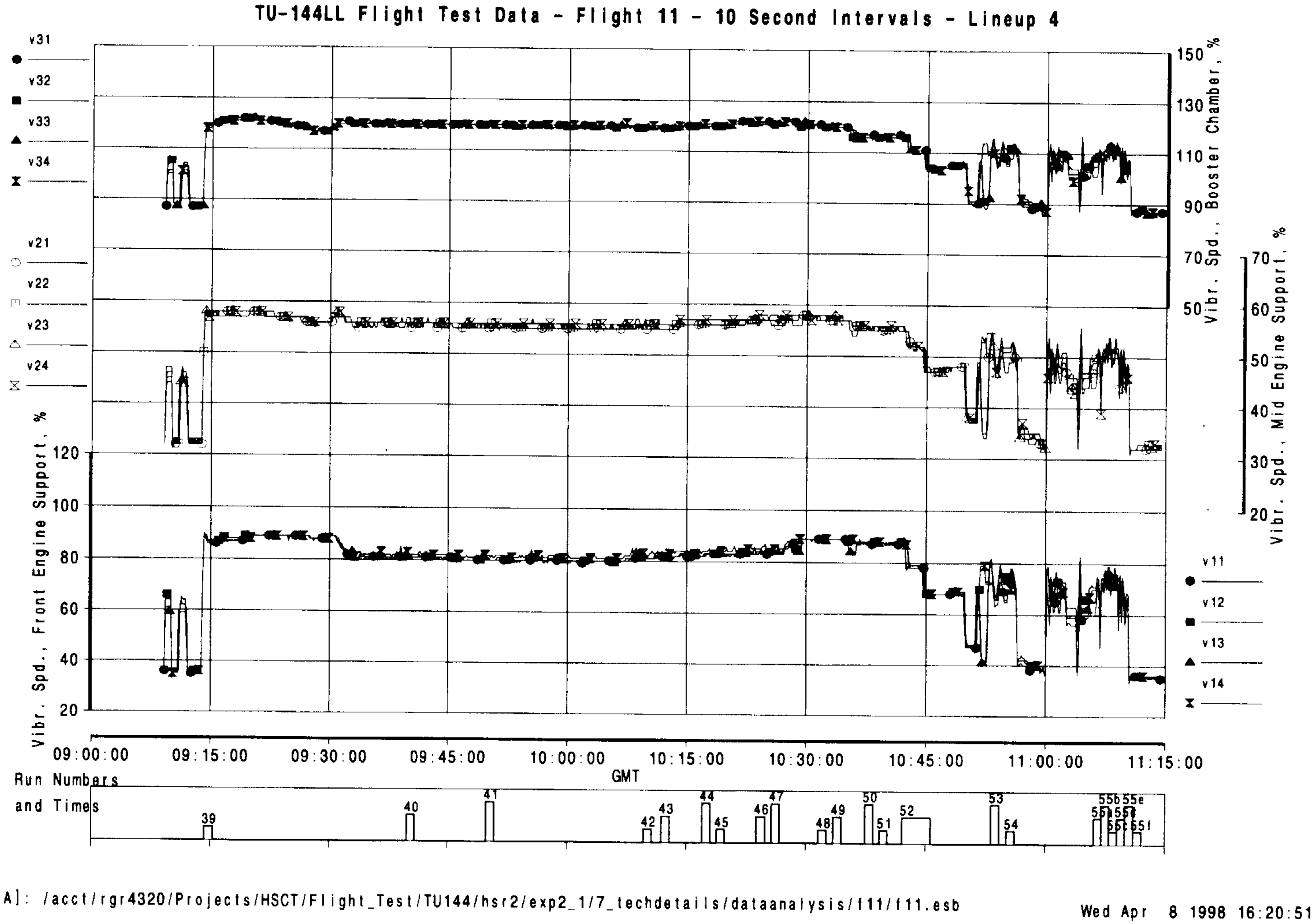


Figure 53 (continued)

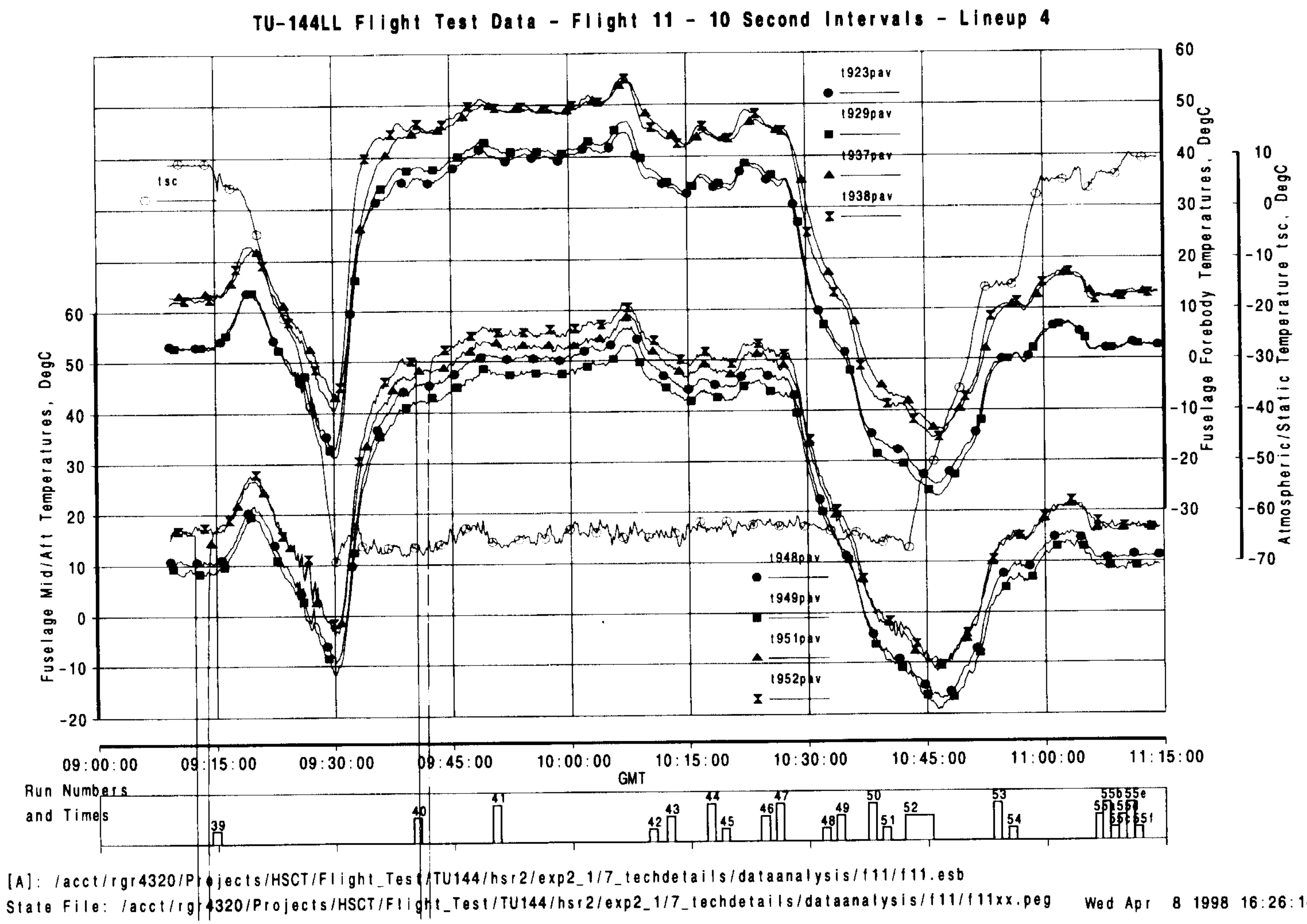


Figure 53 (continued)

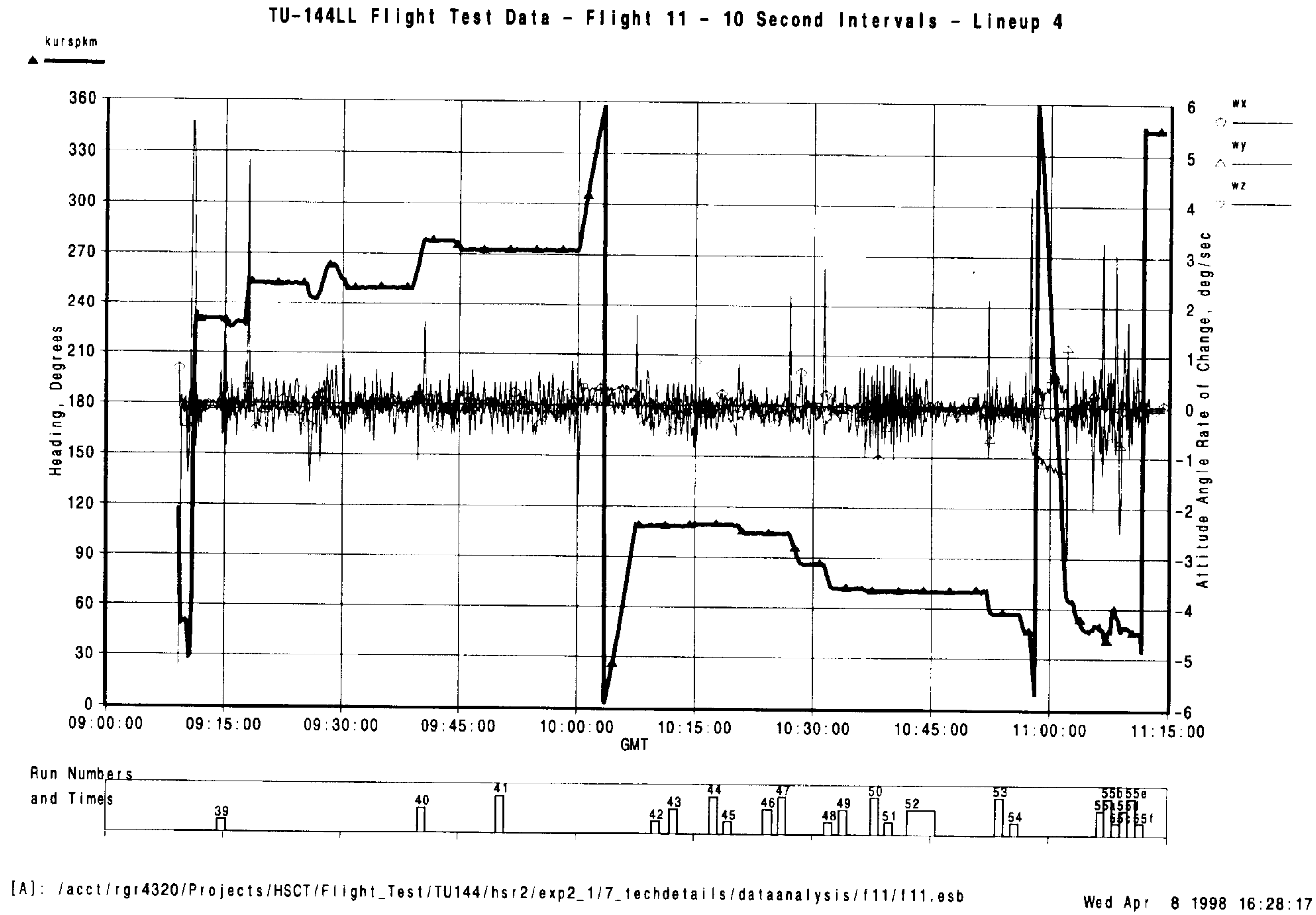


Figure 53 (continued)

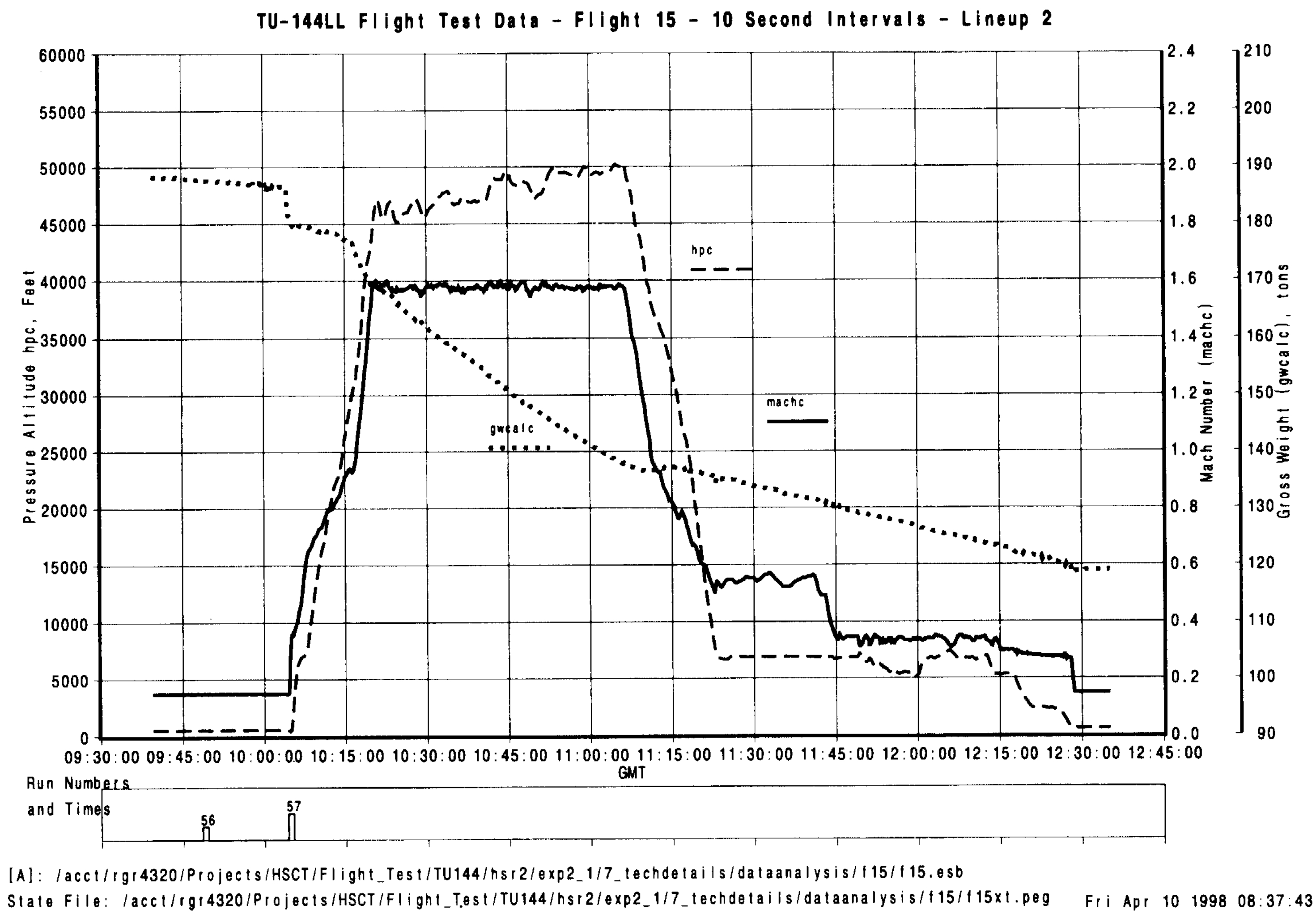


Figure 54: Flight 15 auxiliary data.

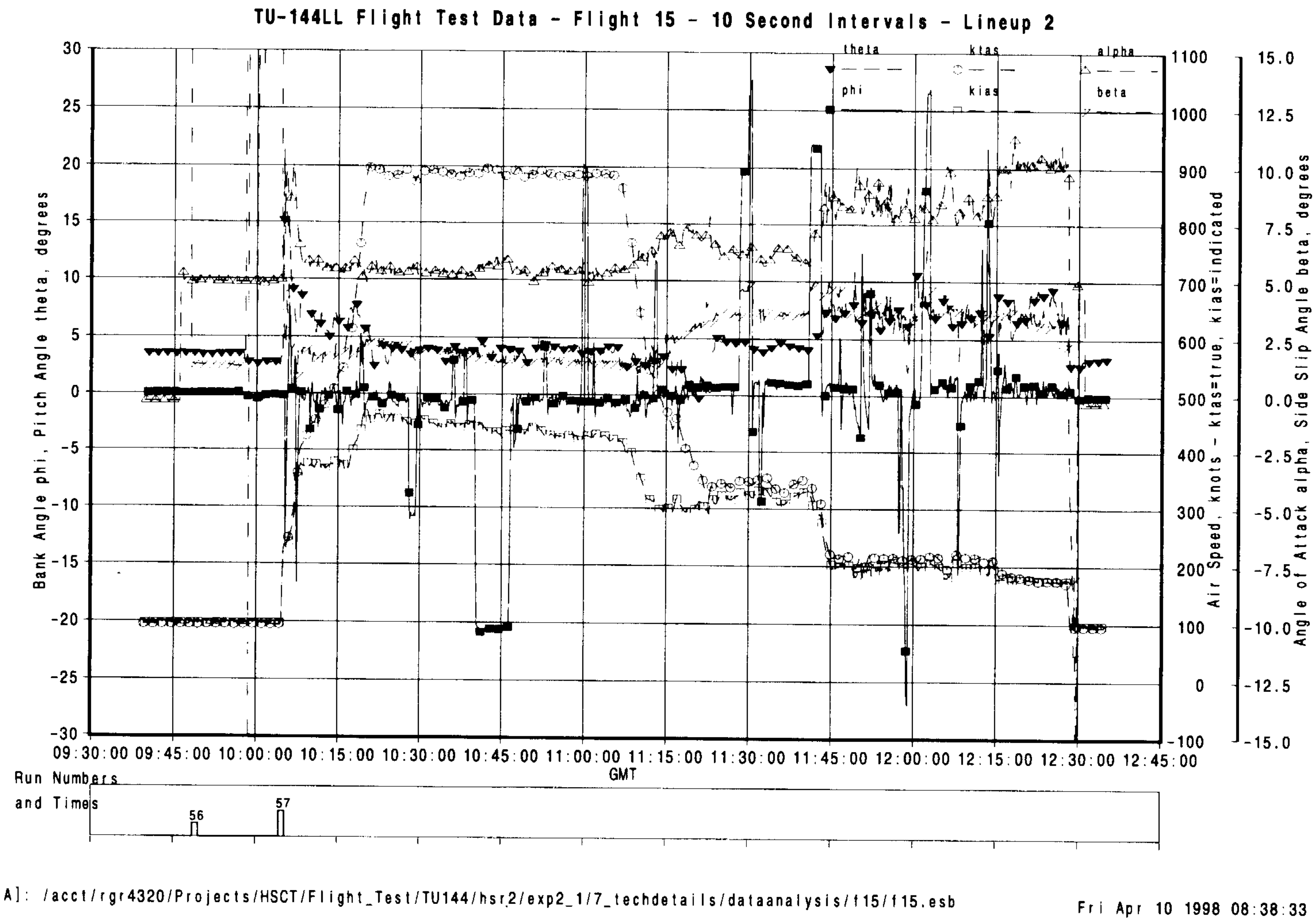


Figure 54 (continued)

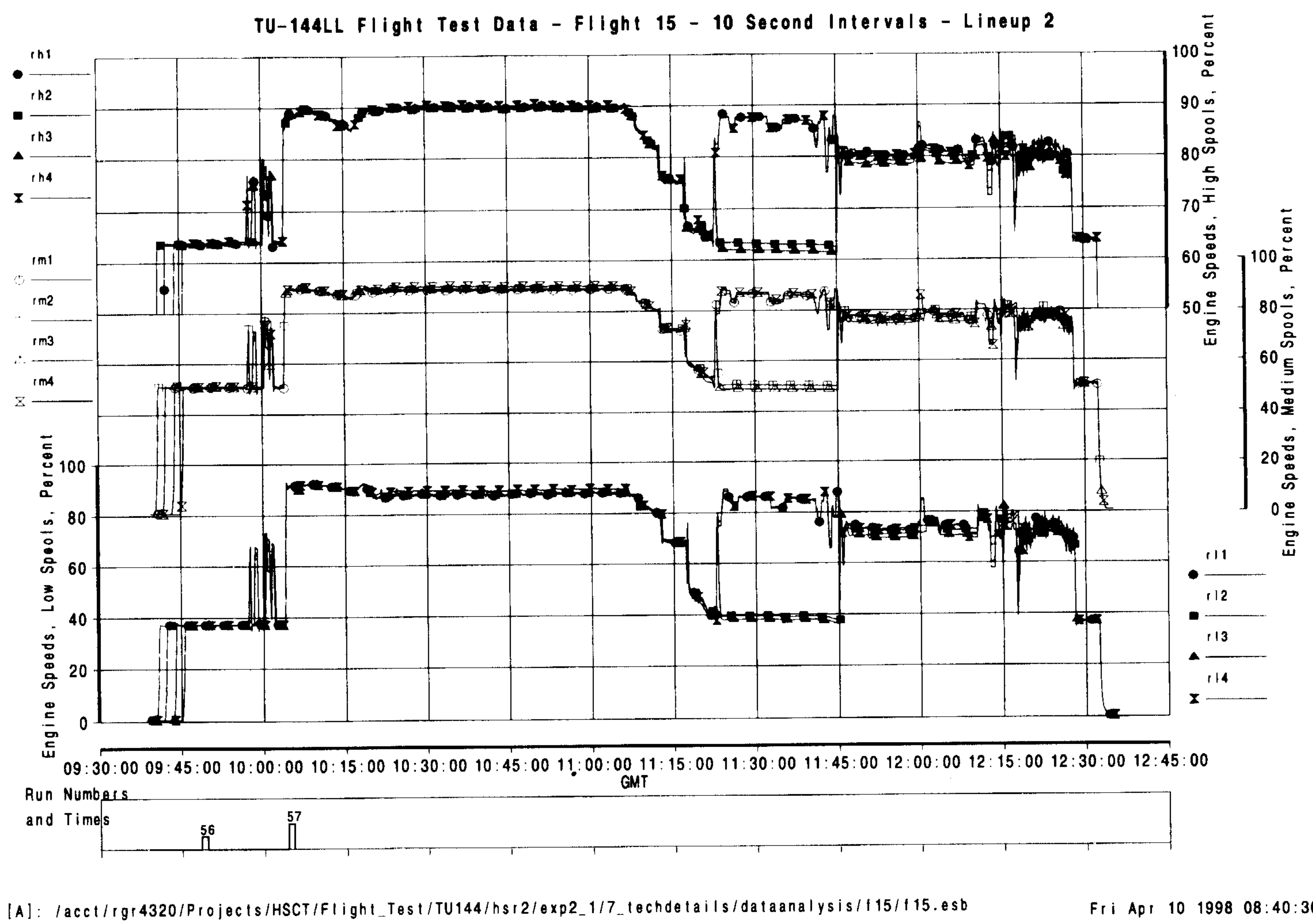


Figure 54 (continued)

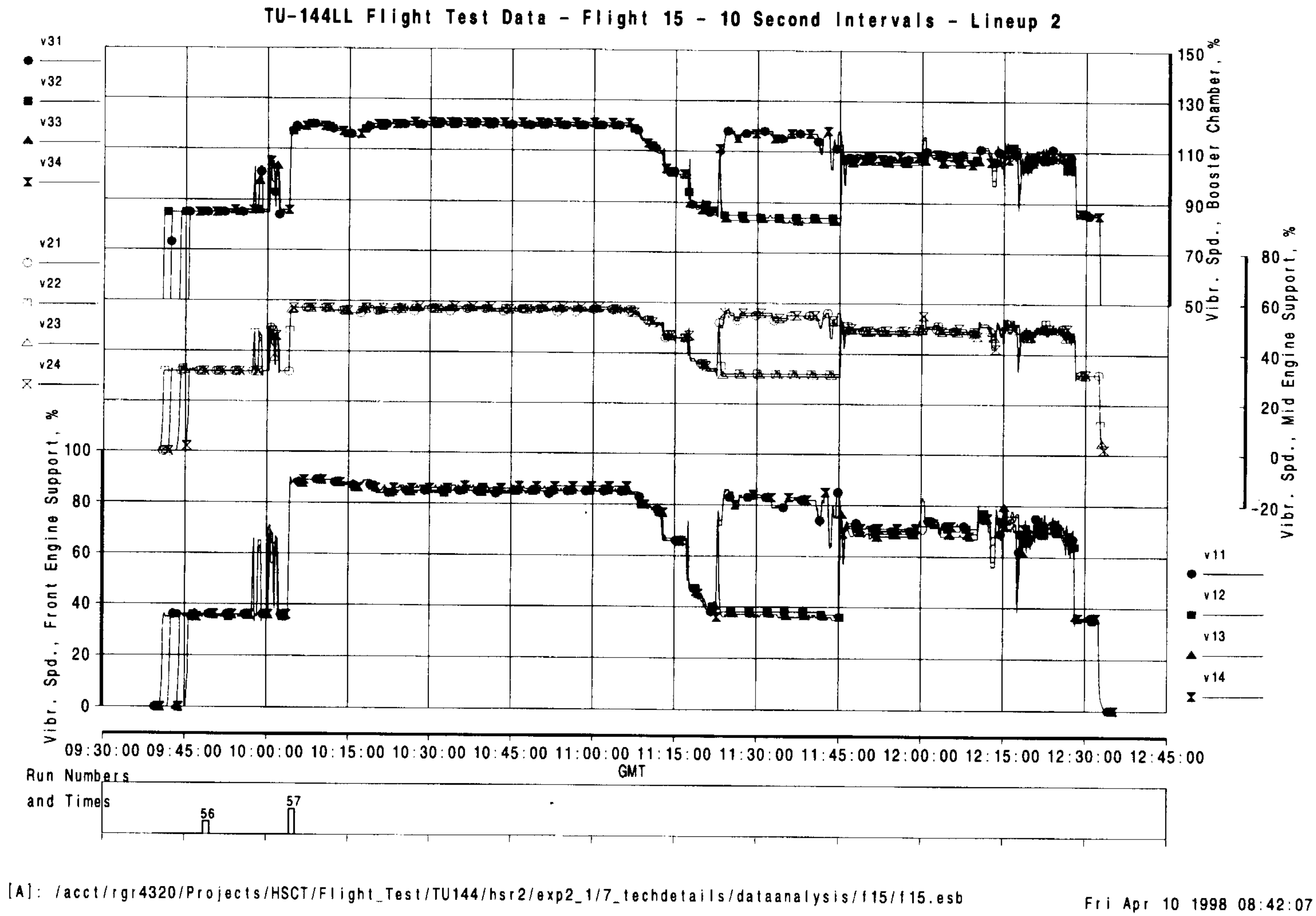


Figure 54 (continued)

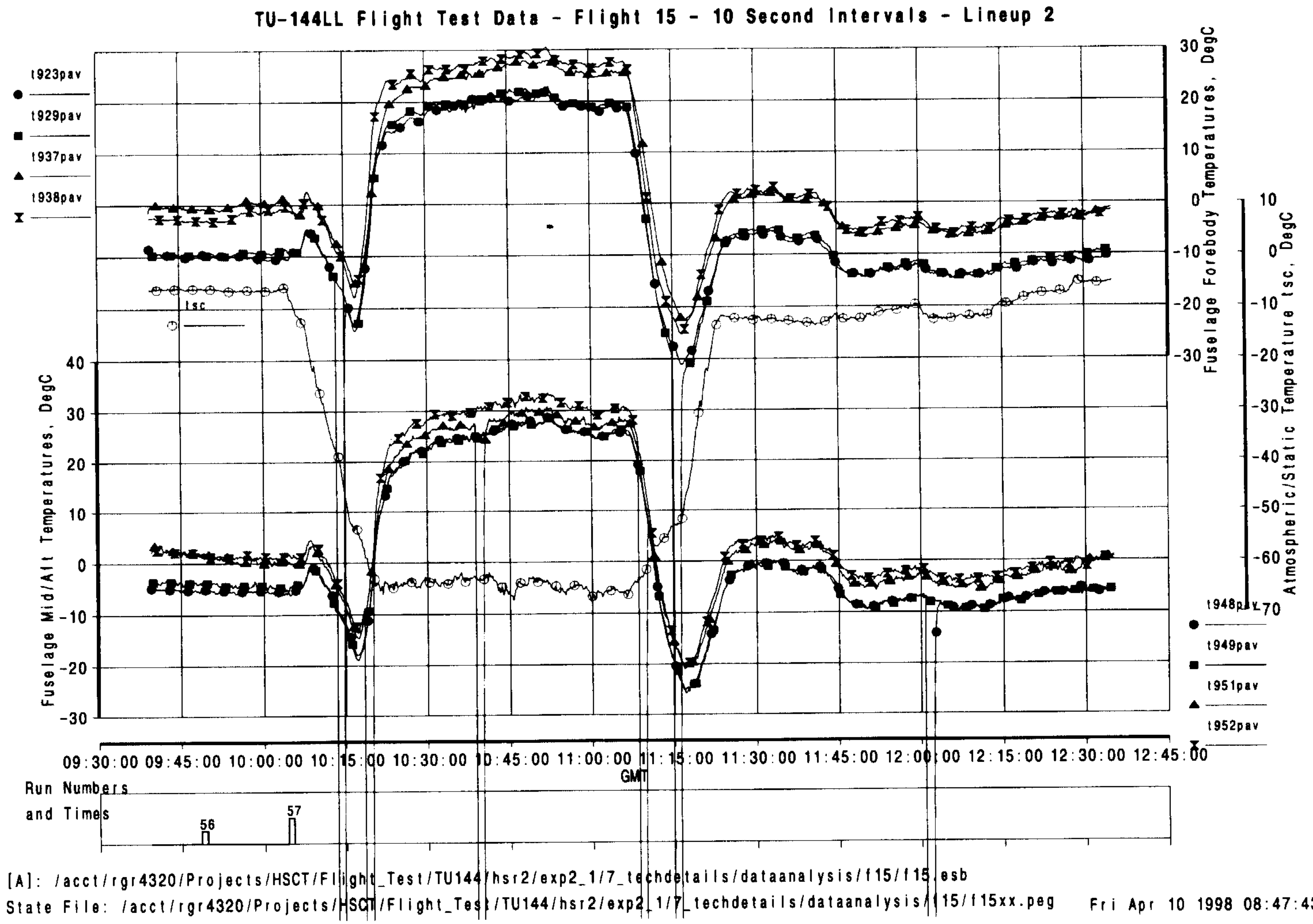


Figure 54 (continued)

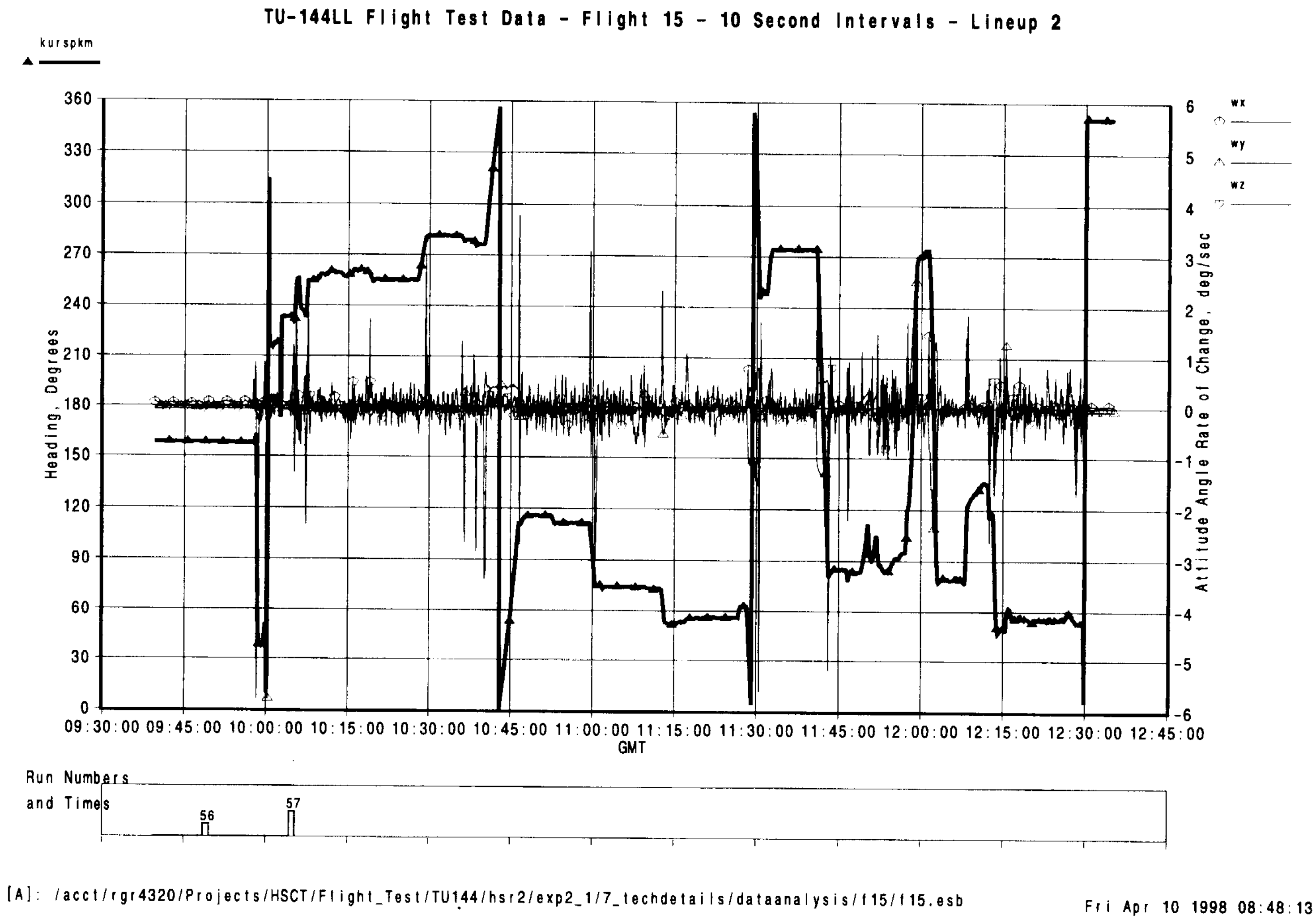


Figure 54 (continued)

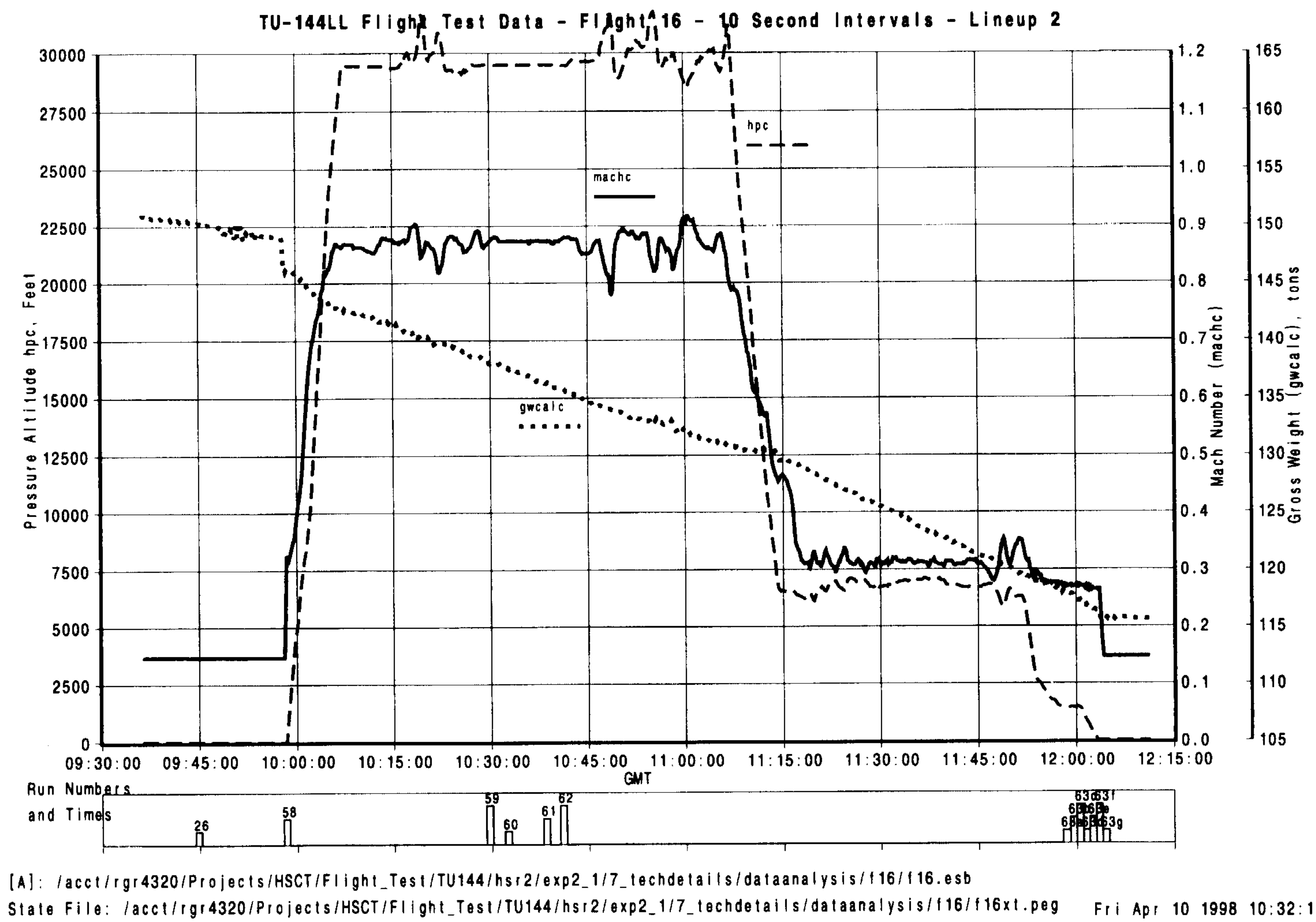
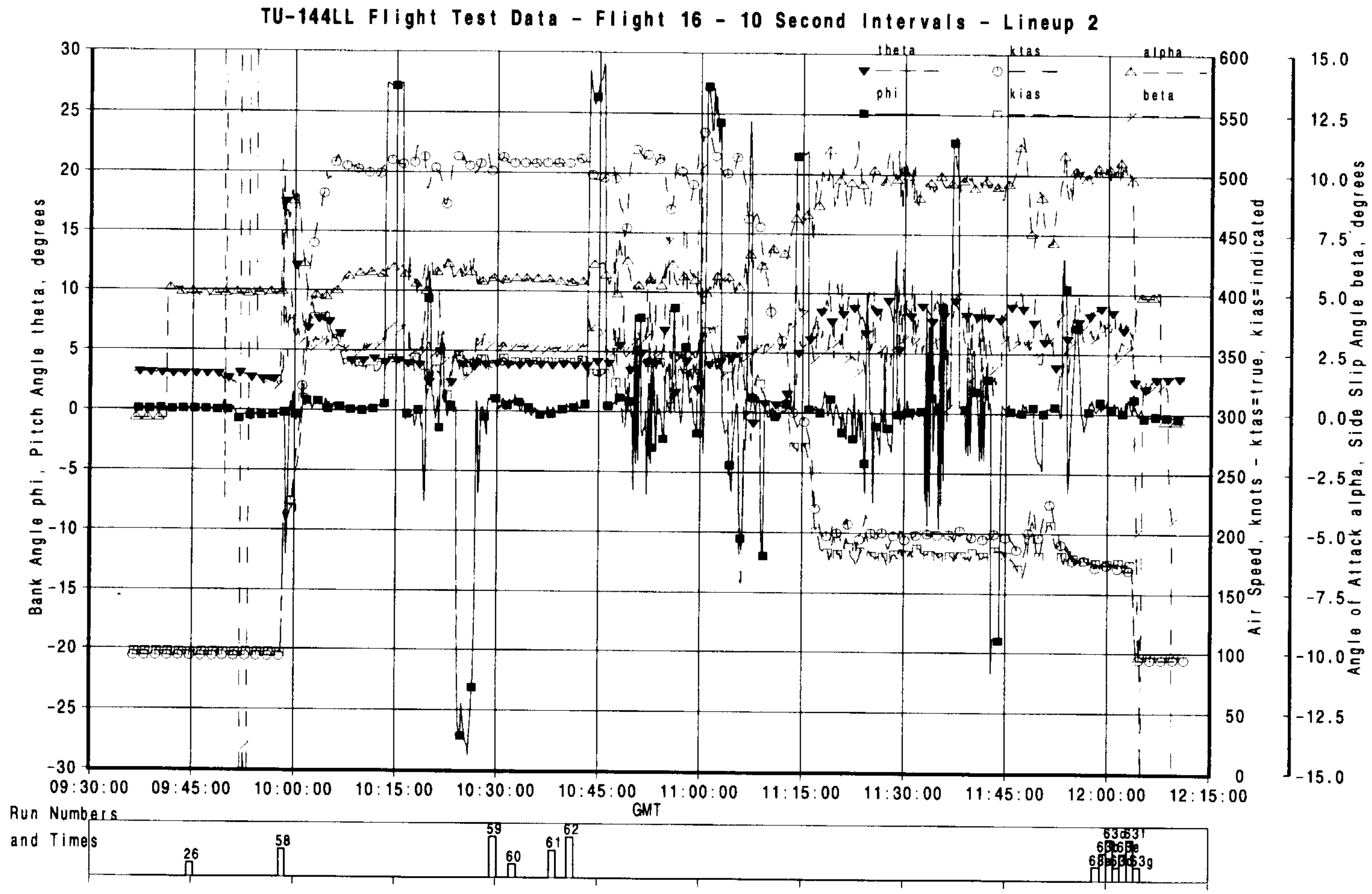


Figure 55: Flight 16 auxiliary data.



[A]: /acct/rgr4320/Projects/HSCT/Flight_Test/TU144/hsr2/exp2_1/7_techdetails/dataanalysis/f16/f16.esb

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Figure 55 (continued)

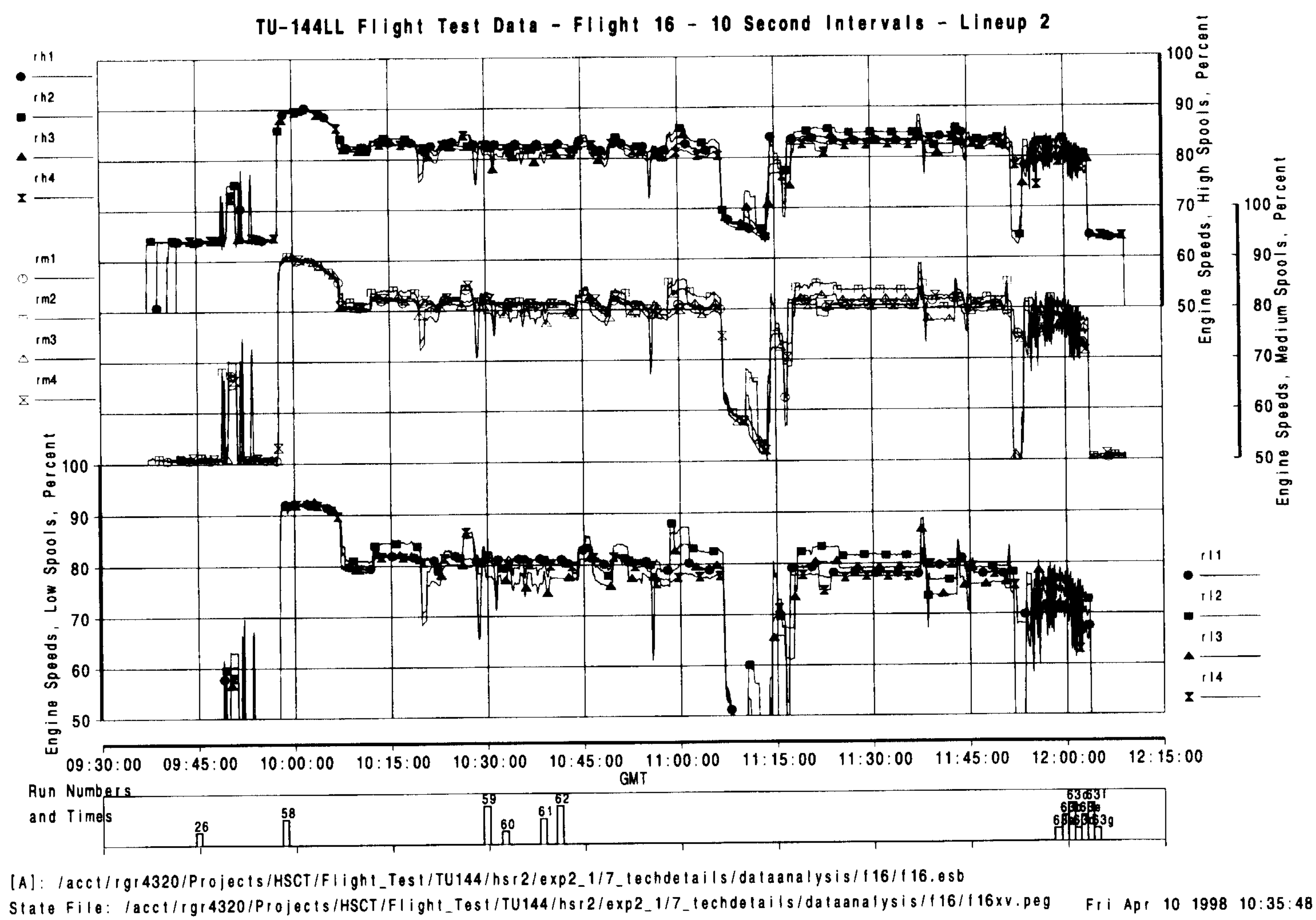


Figure 55 (continued)

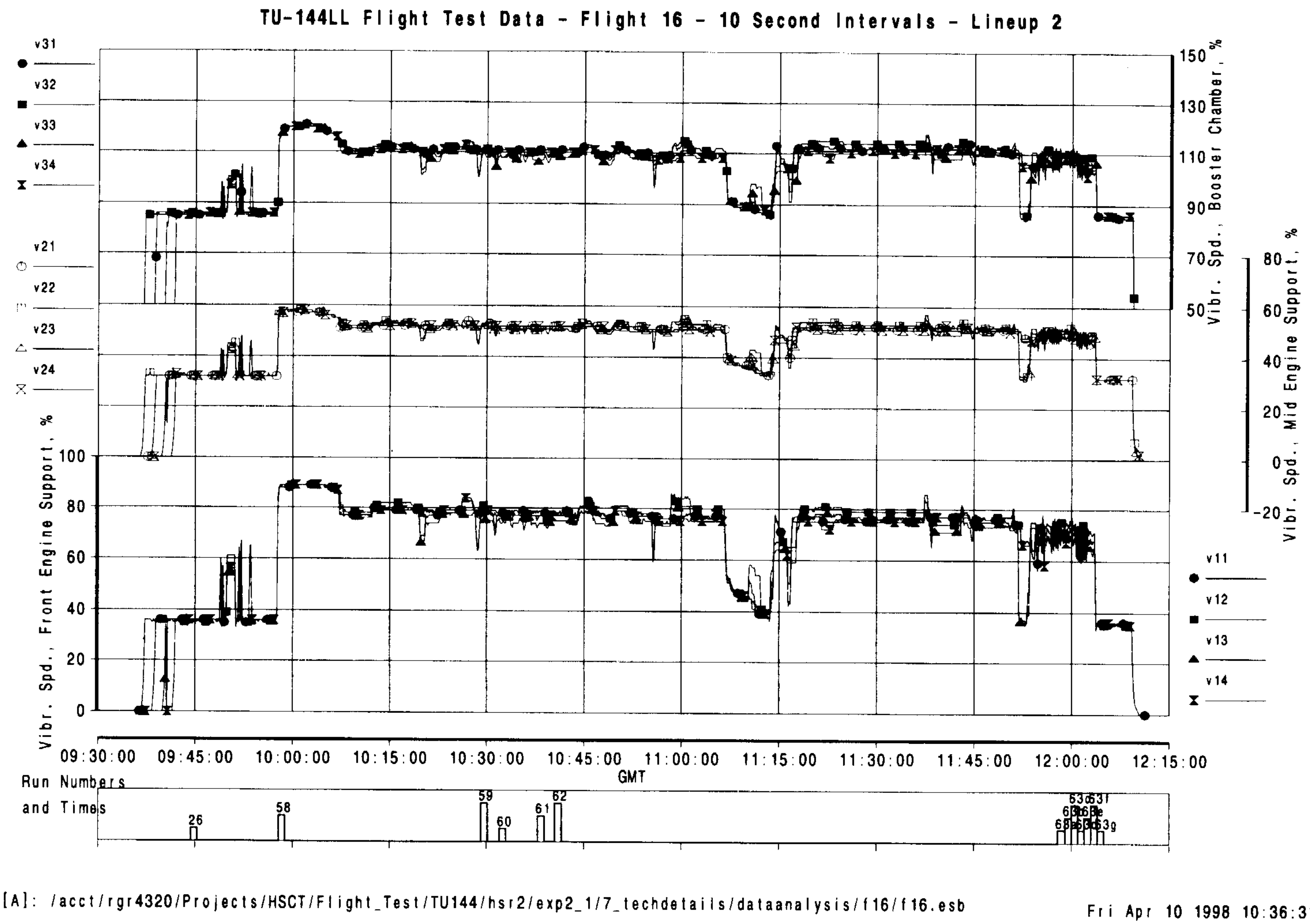
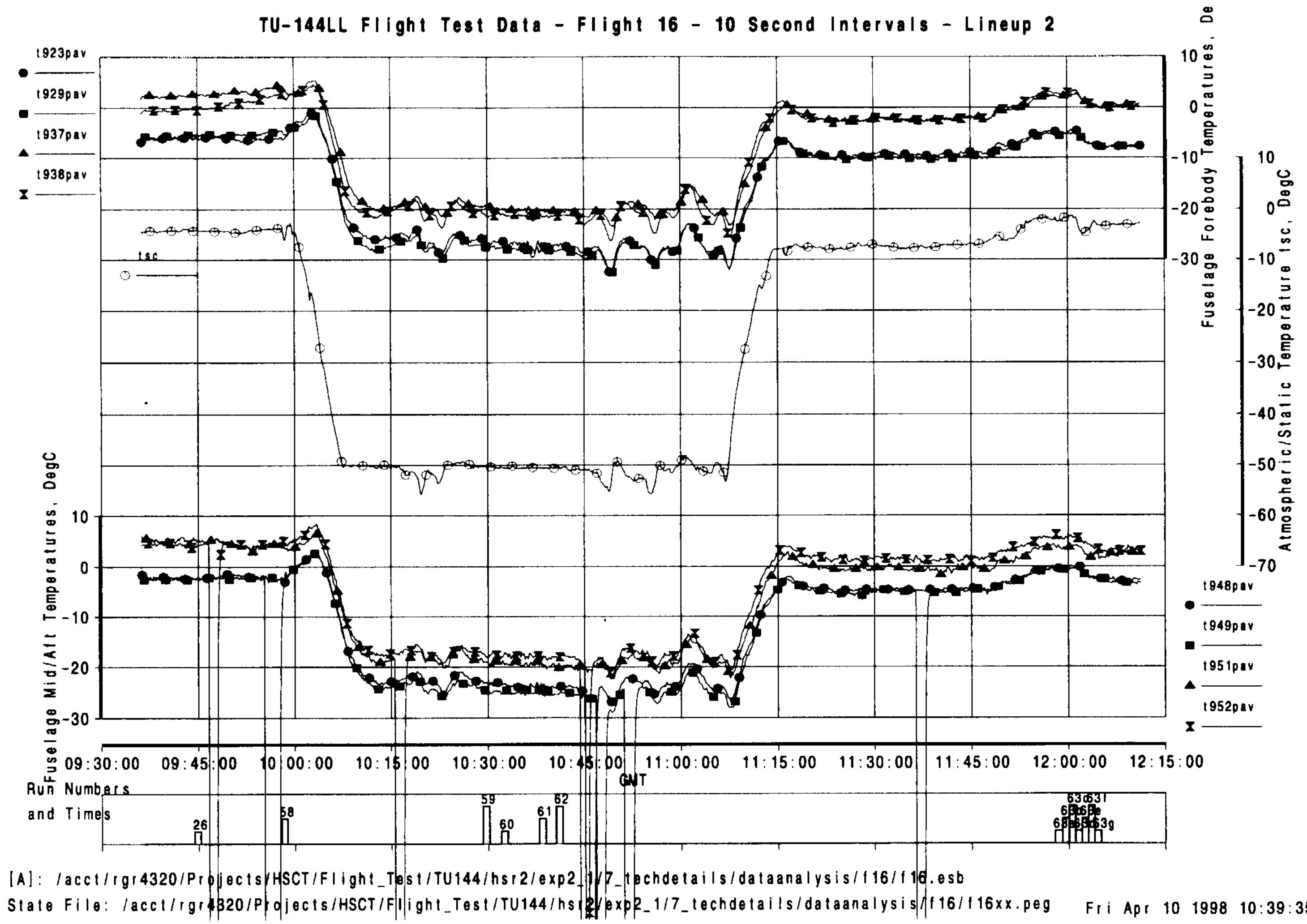


Figure 55 (continued)



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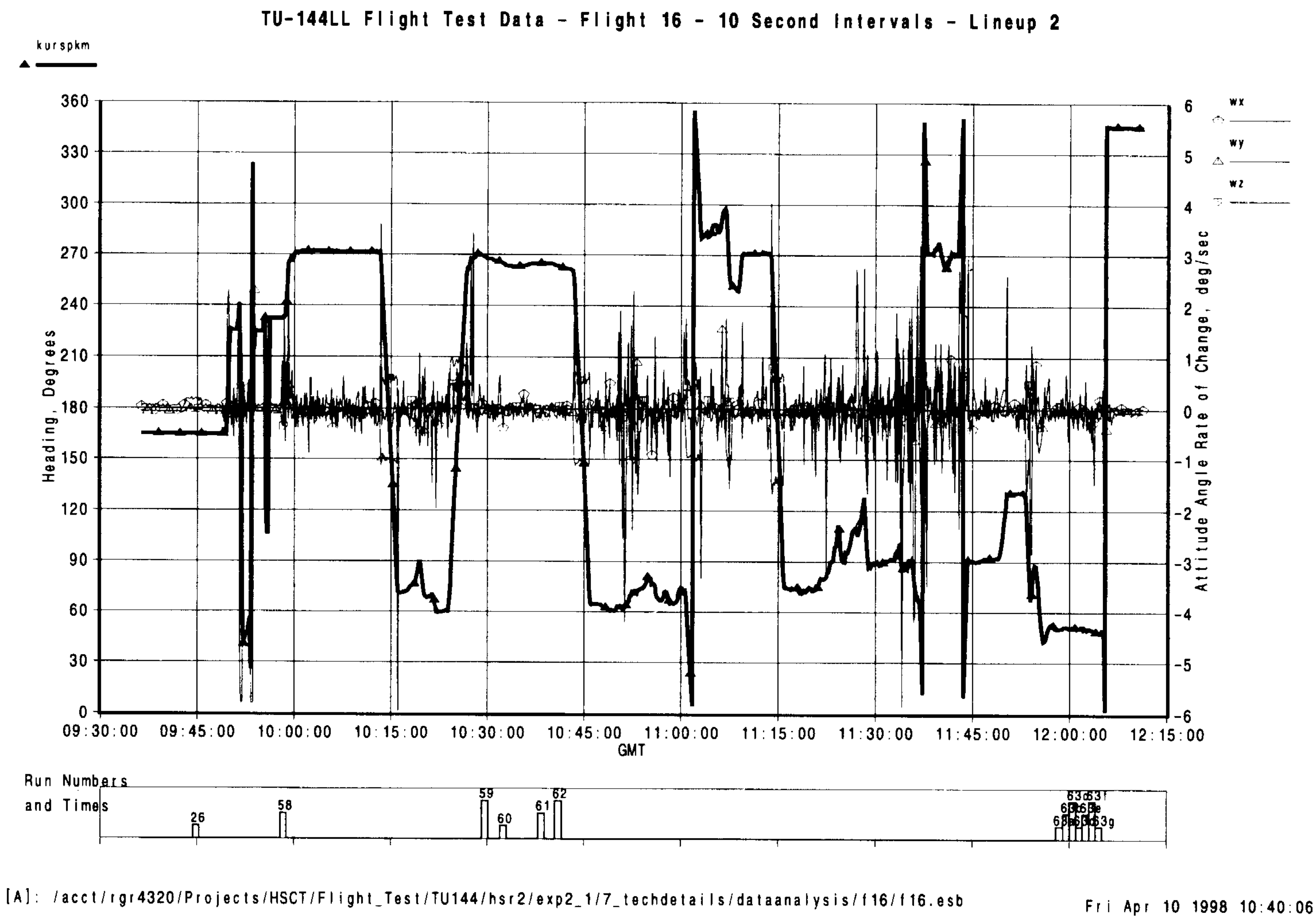

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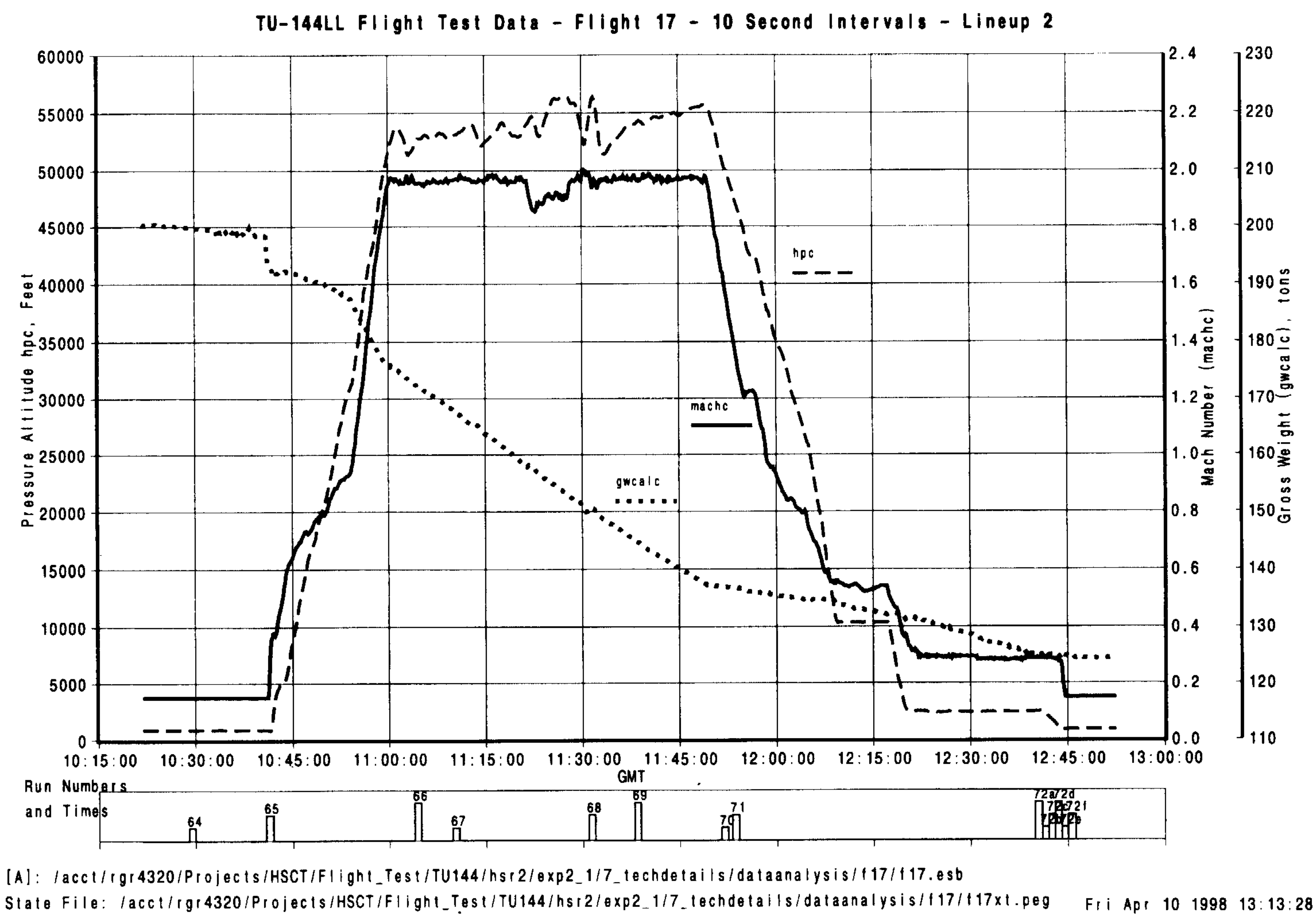


Figure 56: Flight 17 auxiliary data.

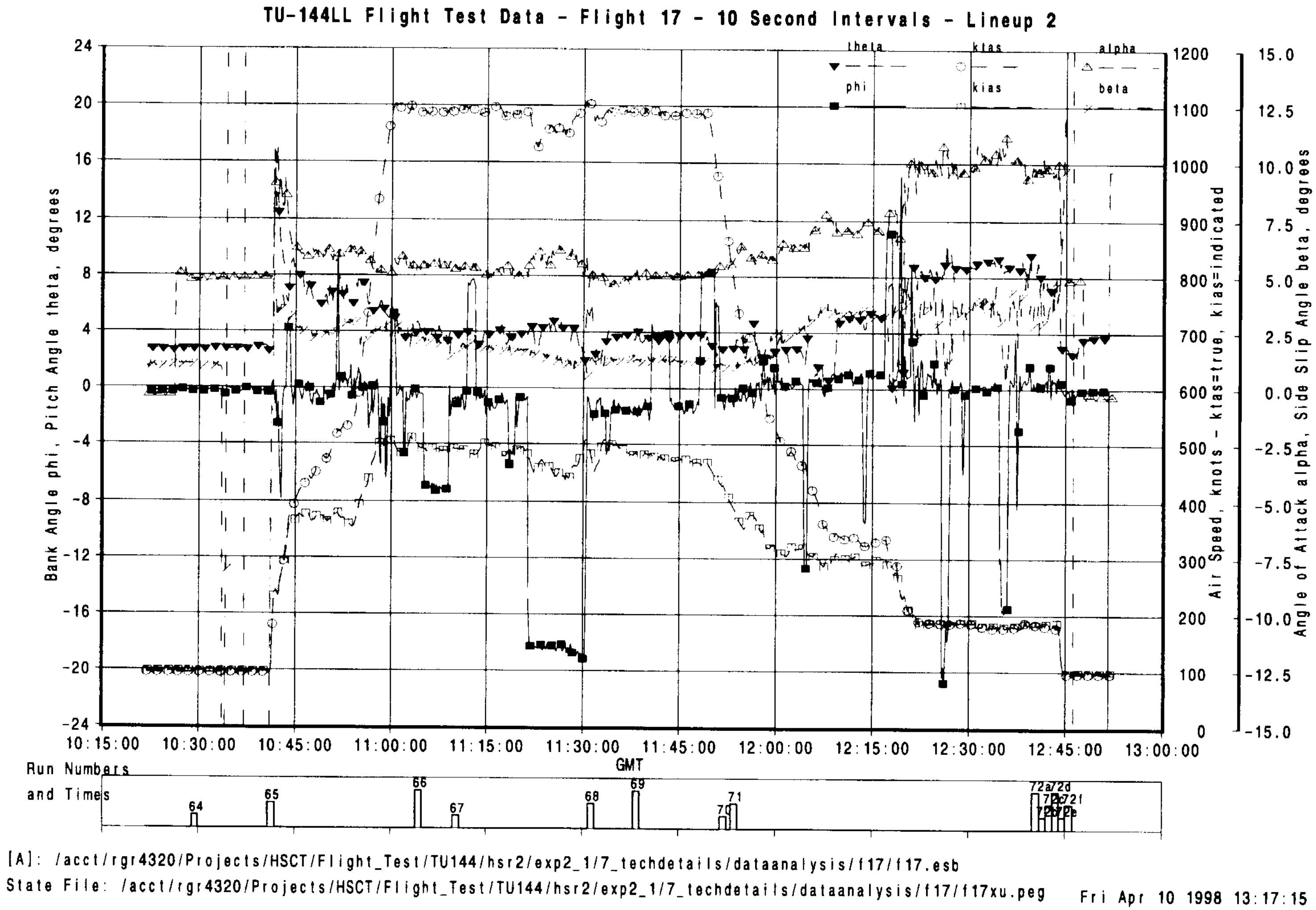
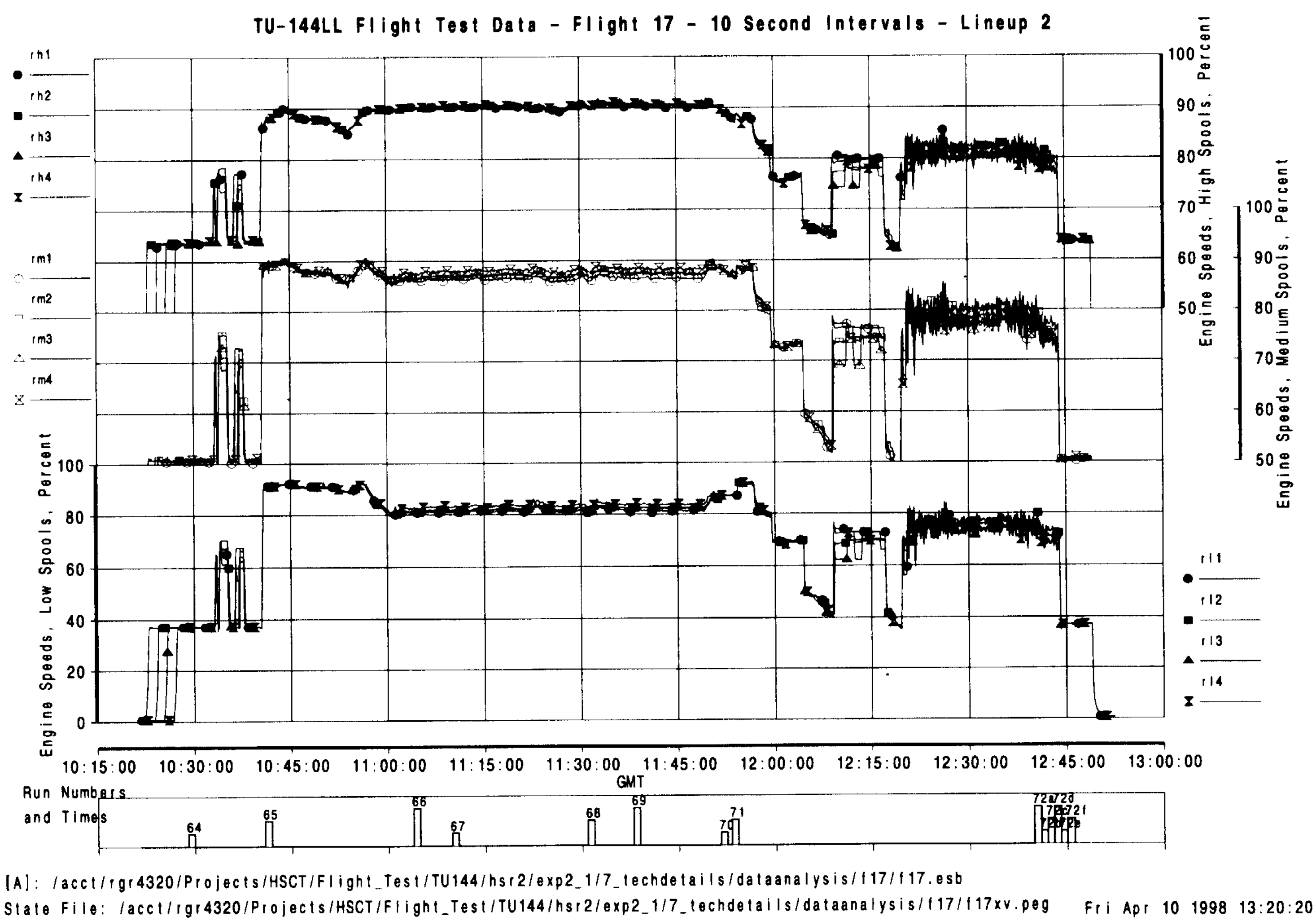


Figure 56 (continued)



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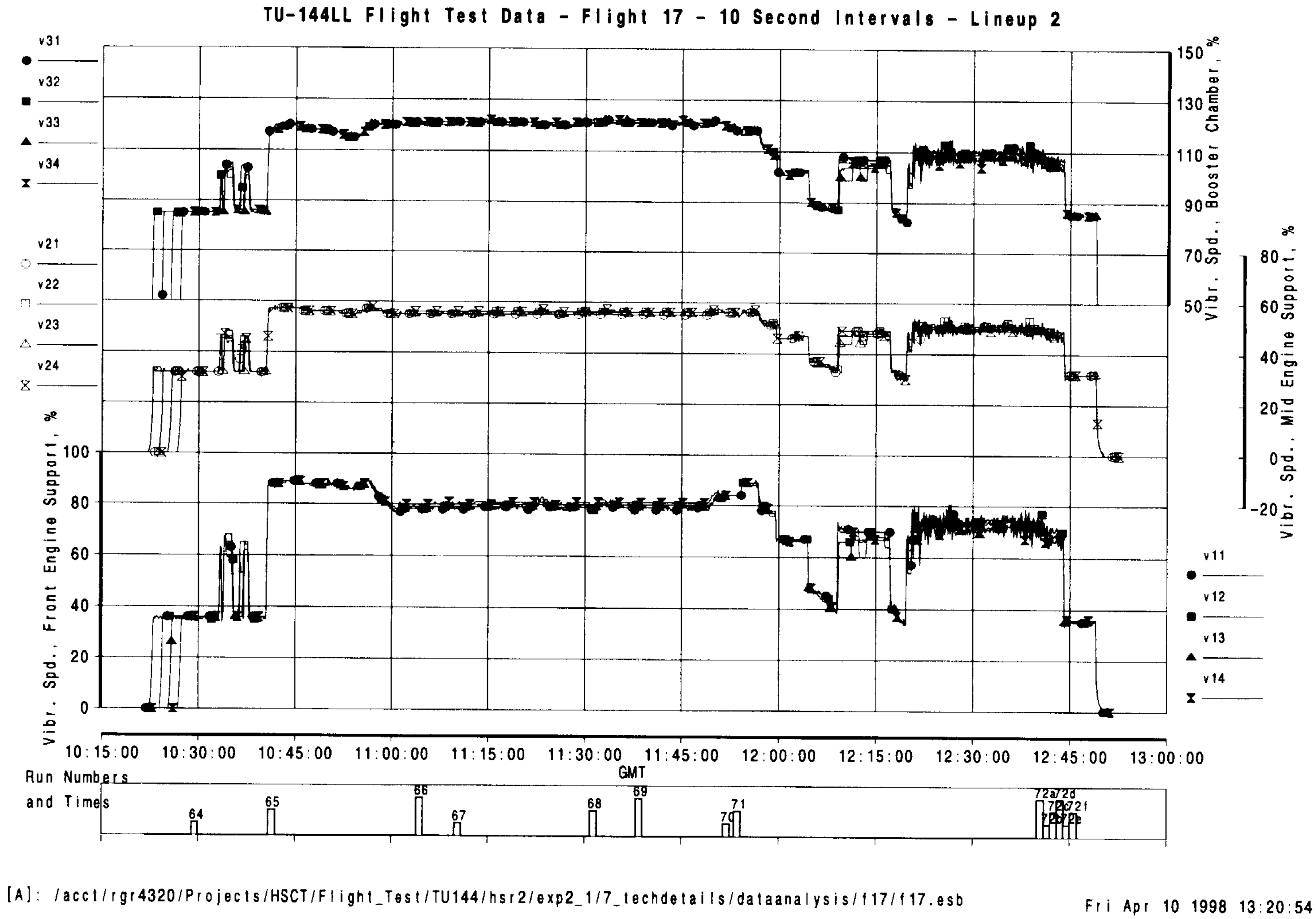

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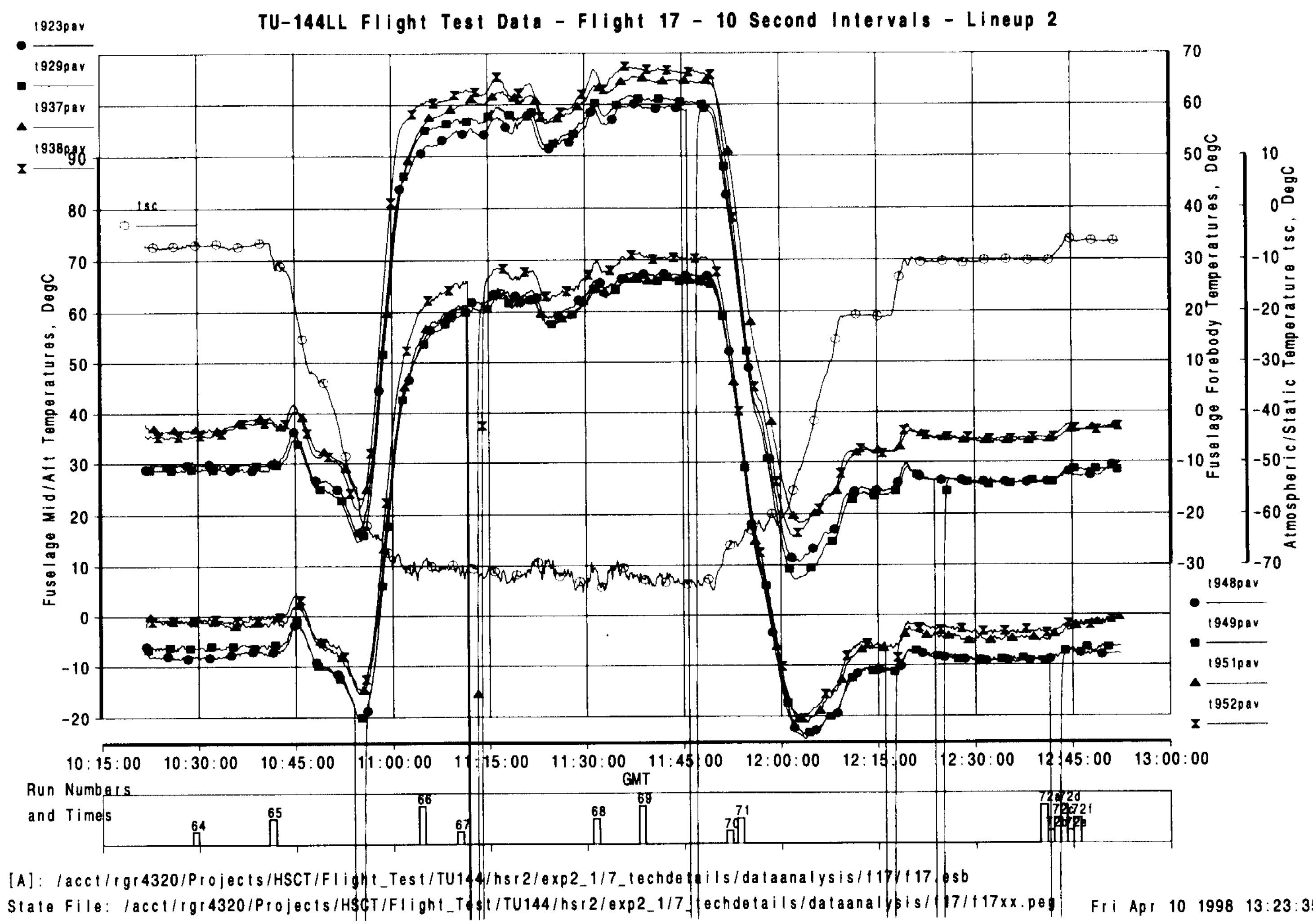

Figure 56 (continued)

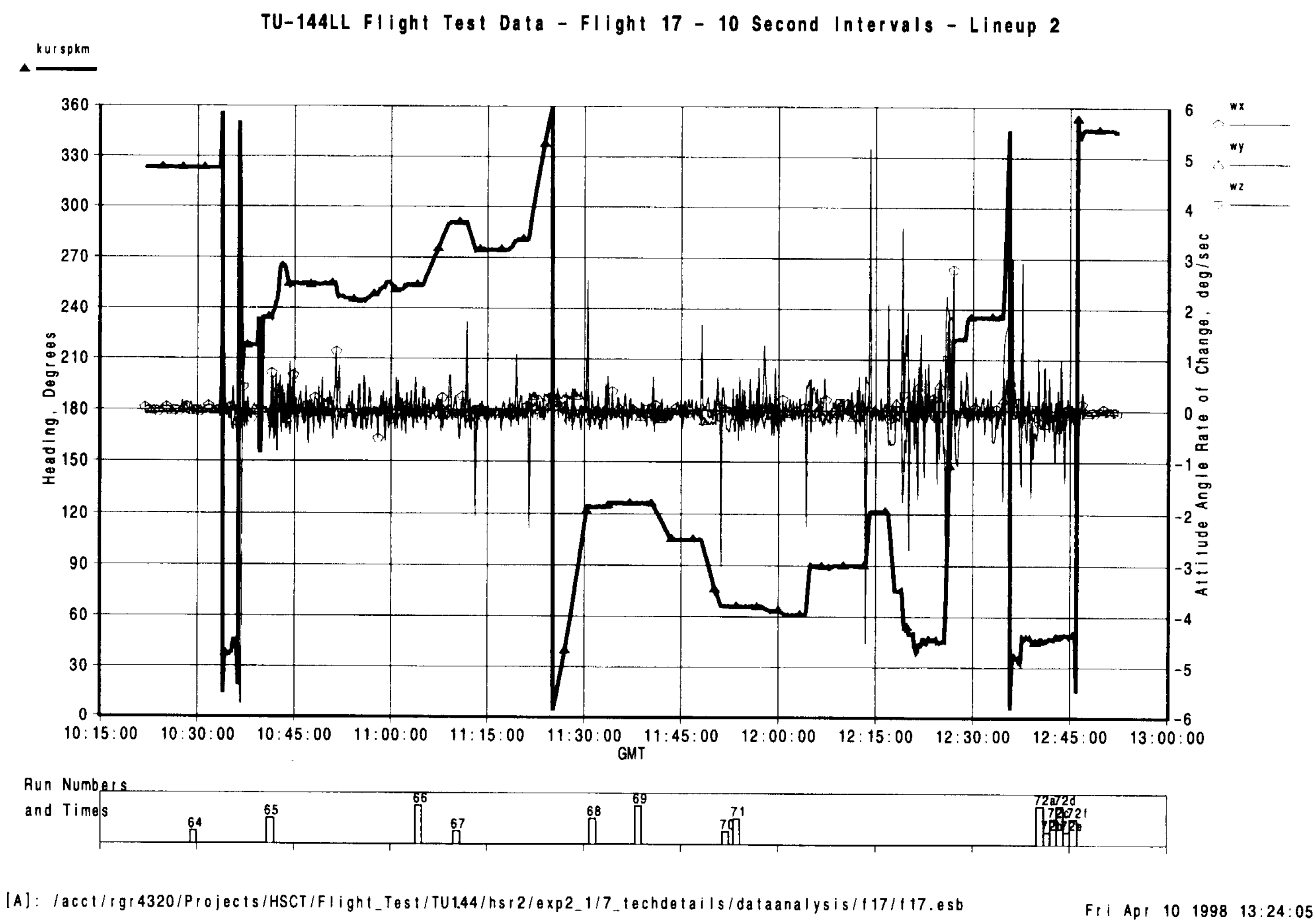

Figure 56 (continued)

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2000	Technical Memorandum

4. TITLE AND SUBTITLE
Flight Test Measurements From The Tu-144LL Structure/Cabin Noise Experiment

5. FUNDING NUMBERS
WU 537-06-37-20

6. AUTHOR(S)
Stephen A. Rizzi, Robert G. Rackl, Eduard V. Andrianov

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

NASA	The Boeing Company	ANTK Tupolev
Langley Research Center	P.O. Box 3707	15 Tupolev Embankment
Hampton, VA 23681-2199	Seattle, WA 98124	Moscow, 111250, Russia

8. PERFORMING ORGANIZATION REPORT NUMBER
L-17950

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Langley Research Center
Hampton, VA 23681-2199

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA/TM-2000-209858

11. SUPPLEMENTARY NOTES
S.A. Rizzi: NASA Langley Research Center;
R.G. Rackl: The Boeing Company; E.V. Andrianov: ANTK Tupolev

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified-Unlimited
Subject Category 71 Distribution: Standard
Availability: NASA CASI (301) 621-0390

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)
During the period September 1997 to February 1998, the Tupolev 144 Supersonic Flying Laboratory was used to obtain data for the purpose of enlarging the data base used by models for the prediction of cabin noise in supersonic passenger airplanes. Measured were: turbulent boundary layer pressure fluctuations on the fuselage in seven instrumented window blanks distributed over the length of the fuselage; structural response with accelerometers on skin panels close to those window blanks; interior noise with microphones at the same fuselage bay stations as those window blanks. Flight test points were chosen to cover much of the TU-144's flight envelope, as well as to obtain as large a unit Reynolds number range as possible at various Mach numbers: takeoff, landing, six subsonic cruise conditions, and eleven supersonic conditions up to Mach 2. Engine runups and reverberation times were measured with a stationary aircraft. The data in the form of time histories of the acoustic signals, together with auxiliary data and basic MATLAB processing modules, are available on CD-R disks.

14. SUBJECT TERMS
Tupolev 144; Tu-144; Tu-144LL; Flight testing; Supersonic passenger airplanes; Supersonic turbulent boundary layer pressure fluctuations; Fuselage vibration; Interior noise; Engine runups; Reverberation time; High speed research

15. NUMBER OF PAGES
200

16. PRICE CODE
A09

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL