SONIC BOOM MEASUREMENT TEST PLAN

NASA-TM-85225

FOR SPACE SHUTTLE STS-5 LAUNCH

Prepared by Herbert R. Henderson

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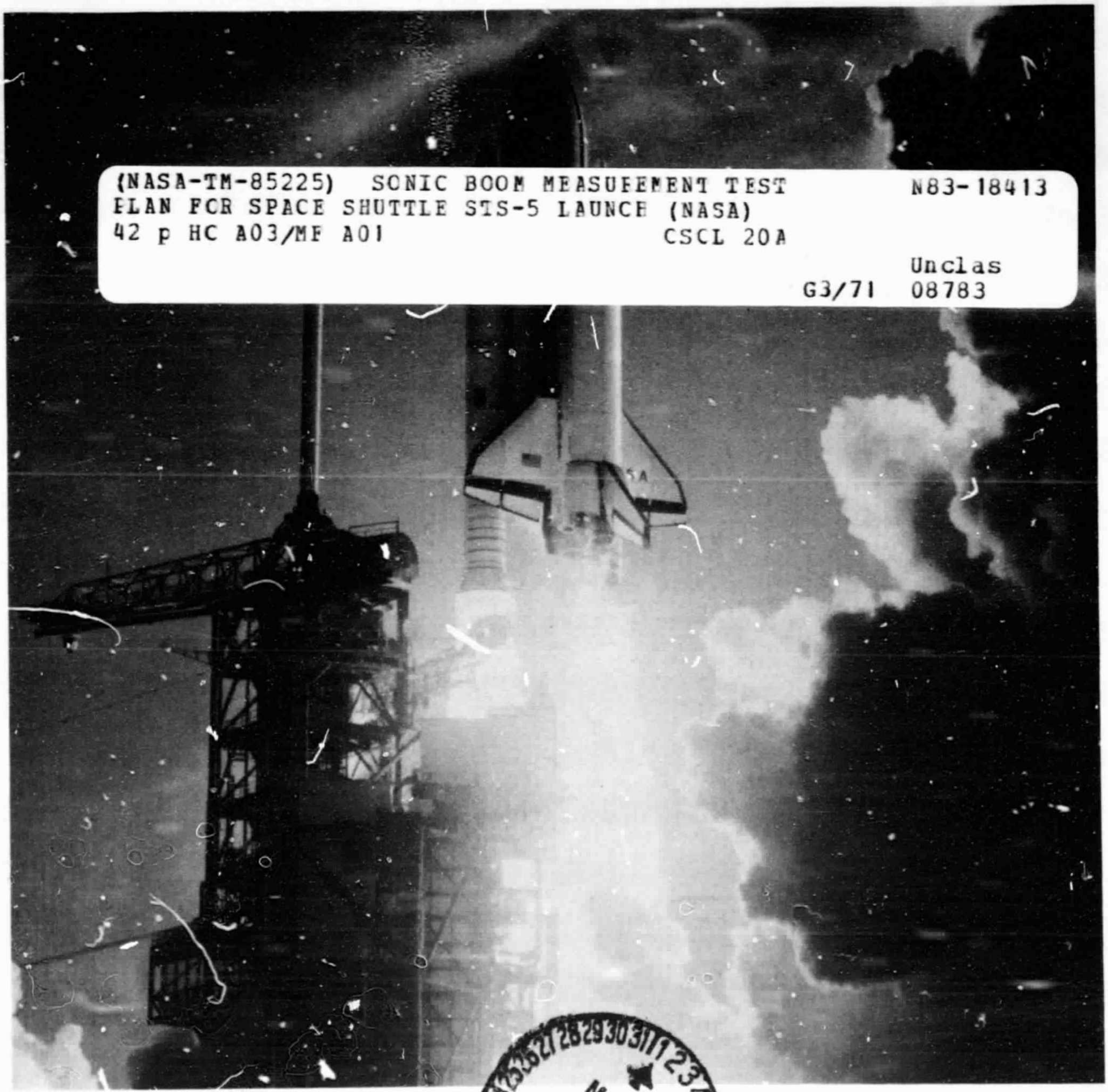

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NASA

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APPROVAL AUTHORITY

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FOR SPACE SHUTTLE STS-5 LAUNCH

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PREFACE

This document relates to an overall plan which describes the Space Shuttle Sonic Boom Measurement Program and in particular, to STS-5 ascent booms. It is supplied as a detailed guide and formal documentation for measurement procedures, system specifications, and general information for others involved in the program. Bv way of review, the Space Shuttle STS-5 will be launched from complex 39A at the Kennedy Space Center, Florida, into a 160 nautical mile circular orbit with a 28.45 degree inclination. Deorbit is scheduled so as to provide the landing at a preselected, primary, secondary or contingency site. The nominal deorbit maneuver is initiated at 97 hours, 16 minutes mission elapsed time during the 65th orbit with a subsequent crosswind landing on runway 17, Rogers Lakebed, Edwards Air Force Base, CA. If the crosswind tests is not possible, then landing will occur on runway 22. A possible weather-alternate landing opportunity is the Kennedy Space Center (runway 33) which occurs at 96 hours, 47 minutes MET on the orbit previous to the nominal landing opportunity.

PURPOSE OF TEST PLAN

This test plan is designed to provide information, guidance, and assignment of responsibilities for the acquisition of sonic boom measurements within the focusing region and laterally from the ground track toward cutoff associated with STS-5 launch. Included is information regarding necessary atmospheric measurements, timing correlation, communications and other required supporting tasks. Details such as data acquisition station locations, measurement systems calibration procedures, predicted sonic boom overpressures, overpressure assignment for each data acquisition station, data recording times on and off, universal coordinated time, and measurement system descriptions are also included.

INTRODUCTION

The primary objective of the STS sonic boom measurement program is to fulfill a committment made by the Space Shuttle Program Office to the U.S. Air Force (Space Division) to investigate and measure Shuttle ascent sonic boom and to assist in validating preflight sonic boom predictions by obtaining sonic boom data from actual over-flights. In addition, the experimental data base and theory validation will assist in defining the launch vehicle and orbiter sonic boom footprint for future activities at Vandenberg Air Force Base, CA.

By way of review, sonic booms have been measured on a very wide variety of aircraft types operating over a wide range of Mach numbers and altitude. (ref. 1). There have been a number of sonic boom measurements made during ascent and reentry of the Apollo and Skylab vehicles (ref. 2). Prediction of the sonic boom characteristics of aircraft using existing theory has been excellent. Good correlation has also been noted for Apollo and Skylab. The Shuttle vehicle geometry and operational characteristics differ from those of Apollo and Skylab and are significantly different from conventional aircraft. Although it is expected that the existing sonic boom theory is applicable to Shuttle, confirmation must await the generation of a suitable experimental data base. Presently, wind tunnel measurements are available for the orbiter (ref. 3). In addition, a series of sonic boom ground measurements associated with the reentry of STS-1, STS-2 and STS-4 were successfully accomplished in April 1981, November 1981, and July 1982, respectively. Details of the STS-1, STS-2 and STS-4 test plans are given in references 4, 5, and 6.

Briefly, STS-1 measurements were acquired using a total of 45 microphones located at eleven positions near the ground flight track from the Pacific coastline to the landing site at Edwards Air Force Base, CA. STS-2 measurements were acquired in the vicinity of the EAFB landing site at four positions. Sixteen microphones were concentrated near the reentry flight track approximately three nautical miles apart. The STS-3 test plan (ref. 7) was to acquire sonic boom measurements to define the lateral extent of the ground exposure pattern along with the overpressure and signature characteristics. These measurements were not acquired on STS-3, because wet lake bed conditions at the primary landing site (Edwards Air Force Base, CA) diverted the orbiter Columbia to the contingency landing site at Northrup strip White Sands Missile Range, New Mexico. The STS-4 sonic boom measurement plan was an update of the STS-3 plan with the same objective of acquiring information relative to lateral distribution of sonic boom from the orbiter originating from a Mach number near 3.3 and altitude of about 97000 feet. Four measurement positions were located east of Bakersfield, CA about 70 n miles from touchdown at EAFB. These stations were located from 7 to 39 n miles laterally to the north side of the re-entry flight track.

Results from STS-1 (Ref. 8), STS-2 and STS-4 were very gratifying in that no surprises were noted and the character of the signature shapes, magnitudes of the overpressures, lateral spread, and the location of the area in which the higher overpressures are experienced was as expected.

The objectives of the STS-5 ascent sonic boom measurement program is to obtain sonic boom measurements at key locations within the focus region and to determine the lateral attenuation rate during ascent in order to assess the validity of existing capability to predict the extent of focus boom area, the number of booms within the various zones (focus and non-focus regions), the overpressures and focus factors. The sonic boom focus region, consists of a region on the ground (in the form of an inverted "horseshoe" pattern) in which higher than nominal overpressures can occur.

Its dimensions are on the order from 300 to 1000 feet in thickness and it extends laterally (for Shuttle) about 45-60 miles to each side of the ground track. The pressures are highest along the ground track and decrease with increasing lateral distance until boom cutoff (due to atmospheric refraction) is reached. In the present program, measurements will be taken across this "horseshoe line" of focus boom at three locations (near the ground track and at two lateral locations out to near cutoff). Provisions have been made in the layout of the measurement locations to obtain the maximum focus pressure within the "focus-line", although the probability of having a measurement station exactly at focus is small (the position of the "focus-line" is based upon an assumed Shuttle flight trajectory and a reference atmosphere). The actual position can vary considerably depending upon actual trajectory and weather conditions. The planned deployment of measurement stations will provide considerable information on the actual location of focal and non-focal areas within the region, its lateral extent and the signature characteristics such that the validity of the current predictive method can be assessed and improved.

MEASUREMENT PLAN

Presentation of the measurement plan includes discussion of the general scope, general flight plan, atmospheric measurements, time synchronization, communications, sonic boom measuring system, and station procedures.

General Scope

This measurement plan consists of deploying nine boats and one buoy system (from boat No. 5) to be used as measurement platforms. These boats will be positioned in the Atlantic Ocean using Loran-C navigation techniques. They will be located approximately 40 n mi down range from the launch site within the predicted focus region ("horseshoe line") resulting from the flight path angle and acceleration profile of the space vehicle during the launch ascent phase of the flight (see figure 1). All boats will be located to the south of the vehicle ground track. Four boats will be located near the vehicle ground track (about 6.5 n mi south) 2 boats at about 26.5 n mi lateral to and south of ground track, and 3 boats about 45 n mi lateral to and south of ground track near lateral boom cutoff. Calculated sonic boom overpressure for each station along with corresponding STS-5 flight conditions and station location is given in tables 1 and 2 respectively. Each of the nine measurements stations will provide six intermediate band FM channels of sonic boom data, a channel for universal time synchronization, and edge-trace voice annotation. The sonic boom measurements will be supported with meteorological measurements (rawinsonde and rocketsonde systems) obtained from the U.S. Air Force (through their Eastern Test Range personnel) located at Cape Canaveral Air Force Station, FL. All measurements will be correlated in time with the STS-5 ascent flight track information. Program responsibilities are identified in figure 2.

General Flight Plan

The STS-5 is scheduled to be a 122 hour flight (nominal duration of 5 days plus 2 days) launched from the Kennedy Space Center on November 11, 1982, at 12:19:00 Greenwich mean time (GMT). The flight test will be achieved in a nominal 160 nautical mile circular orbit with a 28.45 degree inclination. Preparation for deorbit begins at approximately 93 hours mission elapsed time. Following the maneuver to the deorbit altitude, the deorbit maneuver is performed at 97 hours, 16 minutes MET. Entry interface (400,000 ft altitude) occurs at 97 hours: 43 minutes MET with subsequent landing on Rogers Lakebed runway 17 or 22 at Edwards Air Force Base, CA on November 16, 1982, at 6:32 a.m. PST. The above information was obtained from reference 9.

Atmospheric Measurements

Past experience gained on aircraft, Apollo, Skylab, Space Shuttle STS-1, STS-2 and STS-4 programs have shown that it is necessary to have atmospheric information since temperature and wind gradients and low level turbulence can significantly affect not only the sonic boom signature shape but also the ground exposure patterns.

Therefore atmospheric information taken at the surface will be obtained from the Shuttle landing facility, along with upper air observations being taken at Cape Canaveral Air Force Station, FL. Rawinsonde soundings will be taken at launch minus 52 hrs, 25 hrs , 13 hrs, 5 hrs, 1.5 hrs, 1 hr and at launch, with windsonde observations taken at launch minus 26 hrs, 14 hrs, 11 hrs, 7 hrs, 3.5 hrs, and 100 minutes. This data will be used to establish the temperature, pressure and wind characteristics of the atmosphere from near the surface to altitudes of approximately 65 km. This information is furnished and sounding systems operated by the U.S. Air Force through their Eastern Test Range contractor personnel.

Meteorological sounding system - The MSS is a state-of-the-art replacement for the AN/GMD-4. Two MSSs were procured in 1979 for use at Cape Canaveral Air Force Station and Ascension, and a third set was accepted from the manufacturer in Sept. 81 for back-up use at CCAFS. Designed to provide highly precise, 51 point (5.1 sec) smoothed data with the more accurate, faster commutating sondes to meet stringent range test needs, the MSS is also compatible with current standard sondes. The MSS is used to make rawinsonde observations to altitudes of approximately 30 km, rocketsonde observations to approximately 65 km, and windsonde observations to altitudes of approximately 30 km, rocketsonde observations to approximately 65 km, and windsonde observations to at least 20 km. The system receives in the 1660 to 1700 MHz frequency range from balloon-borne radiosondes or rocket borne rocketsondes. The system transmits in the 400-406 MHz frequency range as the up-link carrier for a ranging signal, permitting a phase comparison type range measurement between the tracker and the air-borne instrument. Tracking and ranging functions are controlled by a microprocessor System Control Unit and the entire system, including data handling, is controlled by a 32K word mini-computer. Smoothed tracking information, time correlated with the meteorological data, is stored for future processing to be done immediately after the tracking operation. The use of real-time software combined with application programs in the minicomputer can produce usable processed data in abbreviated formats at the operating site without using other computer facilities. For test support and synpotic soundings, the range's Meteorological Data Reduction (MDRS) is used.

Time Synchronization

In order to enhance the value of the sonic boom measurements precision time synchronization is required. Specifically, a real-time track (range time) is necessary for later data interpretation processes (ray tracing, and shock wave arrival times, etc.) which require that the time, atmospheric conditions, vehicle operating conditions and the STS-5 ascent flight track information be known relative to the time the sonic boom was received at a particular measuring station. Therefore a time synchronization concept will be utilizied and is described in the following paragraph.

Precise time synchronization between the nine sonic boom data acquisition stations (boats) and the STS-5 ascent will be obtained from the "GOES" satellites (Geostationary Operational Environmental Satellite). These satellites are operated by the National Oceanic and Atmospheric Administration, which calls for the positioning of one satellite at approximately 135 degrees west longitude, another at 75 degrees west longitude, and a third to be an in-orbit spare. These satellites are in orbit 36,000 kilometers above the equator, they travel at about 11,000 kilometers per hour and remain continuously above the same spot on earth and thus are termed geostationary. Since they always have the same regions of earth in view, they can provide 24 hour, continuous service.

The sonic boom measuring stations are equipped with satellite synchronized time code clocks which have been designed to receive and decode timing information from the NOAA "GOES" satellite which transmits on a frequency of 468 mHz. The displayed time as well as the electronically produced timing signal will be Universal Coordinated Time (UCT), more commonly referred to as Greenwich Mean Time (GMT). This time base will be recorded on magnetic tape using an IRIG-B format of day-of-year, hours, minutes, and seconds to an accuracy of ± 1.0 millisecond traceable to the National Bureau of Standards.

Communications

The sonic boom coordinator will utilize a RF circuit (HF 10.780 Mhz, upper side band located on the NASA LCU Boat) to call "cape radio" for contact with the Program Principal Investigator (PI) who will be located in the Range Control Center, Cape Canaveral Air Force Station, FL. This will permit the PI to periodically inform the sonic boom coordinator of any STS-5 launch anomalies.

Primary voice communication between the sonic boom coordinator and the 9 data acquisition stations (Boats) will be a NASA approved low band frequency (40.820 MHz). A secondary/backup ground-to-ground voice link (RF circuit) utilizing 49.830 MHz frequency along with various VHF channels will be operational between sonic boom coordinator and project manager. All sonic boom related communications traffic will operate through the sonic boom coordinator position located on board the NASA/LCU Boat.

Sonic Boom Measurement System

Proven aircraft and large spacecraft sonic boom data acquisition systems are to be utilized for ground level sonic boom measurements during STS-5 ascent. These systems, already extensively performance proven, have been used in previous aircraft, Apollo, Skylab, and Shuttle sonic boom measurement programs and consist of pressure transducers, Dynagages (oscillator detector circuit), instrumentation amplifiers, FM magnetic tape recorders, and satellite time code receivers. Specifically, the pressure transducer is a commercially available condenser microphone with a high frequency response to 10 kHz when used with the model DG-605 Dynagage system, with the low end frequency response of approximately -5 dB at .01 Hz. The low end frequency response is made possible by modifying the static pressure equalization vent behind the microphone diaphragm. Basically, the size of the vent was diminished thereby reducing the atmospheric pressure bleed rate. This procedure will allow adequate provisions for system balancing, temperature, and atmospheric pressure changes during field operations.

The Dynagage consists of a radio frequency oscillator coupled to a diode detector circuit whereby small changes in capacity of the pressure transducer will produce relatively large changes in the diode detector. The output of the detector is therefore proportional to the pressure applied to the transducer diaphram. The Dynagage output is fed into an instrumentation amplifier which provides a gain of 0 to 60 dB in steps of 2 dB with a flat frequency response of D.C. to 20 kHz. The measurement system will utilize frequency modulated magnetic tape recorders operating at 30 ips in the intermediate band with a frequency response of D.C. to 10 kHz. AC power will be obtainable on all data acquisition stations (Boats).

This instrumentation will be mounted on commercially available and/or Government owned boats. The placement of the microphones onboard the nine boats, which will vary in size and configuration, is not as straight forward as on reentry measurements in that there is no large ground surface area available that is free from reflections. As such, each measuring station will utilize four microphones flush mounted in a 4 x 4 ft board and will be at a location on the boat that is as free from surrounding obstructions (reflecting or shielding surfaces) as practical and as close to the ocean surface as possible.

All microphones will be covered with wind screens consisting of two layers of cheesecloth. This will minimize the effects of surface winds, temperature variation, and foreign particles that could effect the measurements. The output of the microphones will be routed through the instrumentation amplifiers thus allowing for the setting of a range of overpressure about the predicted level. The provision is necessary in order to cover the range of predicted focus boom levels that result from using various values of a focus factor (from 2 to 6 times nominal boom). In addition, a range of settings allows for overpressure variations resulting from unusual atmospheric conditions. Each station will record 6 channels of overpressure data, time code signal, and edge track voice annotation.

All tape recorders are laboratory calibrated periodically for proper record levels, speeds, and frequency response. The microphone systems are calibrated for frequency response according to factory specifications utilizing the infrasonic piston phone technique. In the field all tape recorder data channels are calibrated using a precision voltage source to verify center frequency stability, the microphones are calibrated using an acoustical calibrator which generates a known sound pressure level in a closed cavity at a fixed frequency of 1 kHz. Calibrations are performed at both "pre" and "post" flight conditions and will establish the amplitude sensitivity of the system which will verify an end-to-end acoustical calibration.

Floating Sonic Boom Data Acquisition Mini-System

The mini-system is a self contained waterborne microcomputer-based sonic boom data acquisition system. This system will be employed to provide supplementary data to aid in the characterization of space Shuttle STS-5 ascent sonic boom footprint.

The mini-system is composed of a solid state pressure transducer, 8-bit analog to digital converter, 6800 based CPU, and digital cassette recorder, all powered by a lithium battery pack. The electronics package is secured to a specially designed floatation system that allows deployment from a small craft. Once on station the mini-system is remotely activated from several miles distant via RF link.

Pressure data from the solid state piezoresistive pressure transducer is amplified and conditioned by a low noise amplifier/low pass filter and digitized with 8-bit resolution at a sampling rate of 1000 Hz. Digitized pressure data is outputed to the cassette recorder by the CPU in real-time. The CPU controls system operation providing data recording, playback and calibration modes of operation. Frequency response is ± 0.5 db from 0.1-300 Hz. The RF link consists of a handheld 2 watt 450 MHz dual-tone encoded transmitter and a dual-tone decoded receiver. The mini-system can be activated to record events up to 6 minutes in duration. This system will be operated approximately 500 yards off the back of the boat at station 5 during the Shuttle launch.

Station Procedures

The following information applies to Station 1 through 9.

a. Before instrumentation is powered up, ascertain that line voltage is reading 115 VAC (tolerance will be plus 2 Volts minus 0).

b. Two hour warm-up for all instrumentation.

c. Station operator is responsible for boat position verification for STS-5 launch.

d. All measurement stations at the time of launch will position the bow of the boat to the east.

e. When STS-5 sonic boom is received record boom arrival time and ship position on the assigned annotation channel.

f. Day of launch a fresh roll of magnetic tape will be loaded for the mission. Preflight and postflight calibrations along with the STS-5 sonic boom data will be recorded on a single roll of tape. This tape will be annotated according to procedures.

g. Voice communications between all measurement stations (boats) and the sonic boom coordination will utilize NASA approved low band frequency 40.870 MHz.

h. Utilization of communication circuits will be held to a minimum. There will be no communication between measurement stations unless your station is called. If an instrumentation failure exists, call sonic boom coordinator and the appropriate personnel will be notified.

i. All tape recorder data channels will be calibrated at both pre and post flight situations using a precision one volt RMS source to verify center frequency stability.

j. All microphones will be calibrated at a pre and post flight conditions using 130 dB sound pressure level at a fixed frequency of 1 KHz.

k. All information pertaining to calibrations, overpressure settings, and amplifier gains will be recorded on the assigned voice annotation channel.

l. Greenwich Mean Time (GMT) will be recorded on the assigned timing channel during all calibrations and while recording actual boom data.

m. Sonic Boom Coordinator will give "recorders on" and "recorders off" command for all sonic boom measurement stations during STS-5 launch.

n. All pertinent data will be recorded on data sheets; i.e., microphone number, tape channel number, calibration levels, weather and sea state conditions, aircraft in vicinity of station while calibrating instrumentation or during the actual launch. The systems operator will provide a personal assessment of the nature of the sonic booms, i.e., single or double, light or heavy and rumbles, etc.

o. Stations experiencing any problems affecting this sonic boom measurement program will notify Sonic Boom Coordinator as soon as possible.

p. THERE WILL BE NO RADIO FREQUENCY TRANSMISSION DURING DATA RECORDING

q. A complete scan through all data channels will be repeated at regular intervals while the data acquisition station is operational.

r. Meteorological surface data will be recorded at stations two and seven, one hour prior to Shuttle launch and as soon as possible after boom arrival.

Mini-System Station Procedures

The following information applies to the mini-system located on station 5.

1. Prior to the execution of a functional checkout and calibration verification measure the battery pack open circuit voltages. Voltages should be 27.3 ± 0.5 V and 11.7 ± 0.3 V respectively.

2. Perform functional checkout and calibration tests with calibrator set for an output of 137 db @ 100 Hz.

3. While recording calibration data measure battery pack voltages. Voltages should be 24 ± 1 V and 10.5 ± 1 V respectively.

4. One hour prior to launch a fresh tape that has been cycled twice (rewound twice) shall be inserted in the recorder.

5. Thirty minutes prior to launch the system will be placed in the standby mode and deployed.

6. Upon receipt of a "Recorders On" command 3 ON commands 15 seconds each in duration will be transmitted in succession.

7. Upon receipt of a "Recorder Off" command 3 OFF commands 15 seconds each in duration will transmitted in succession.

NOTE

Specific details for each station, including event times, pressure level assignments, calibration and overpressure range settings are contained on the following pages.

Event Times

Stations 1 through 9

Day 1 (Launch)

- Arrive at measurement station at launch time minus 3 hours.

- Ready to record data launch time minus 1 hour.

- "Recorders on" command will be given by sonic boom coordinator.

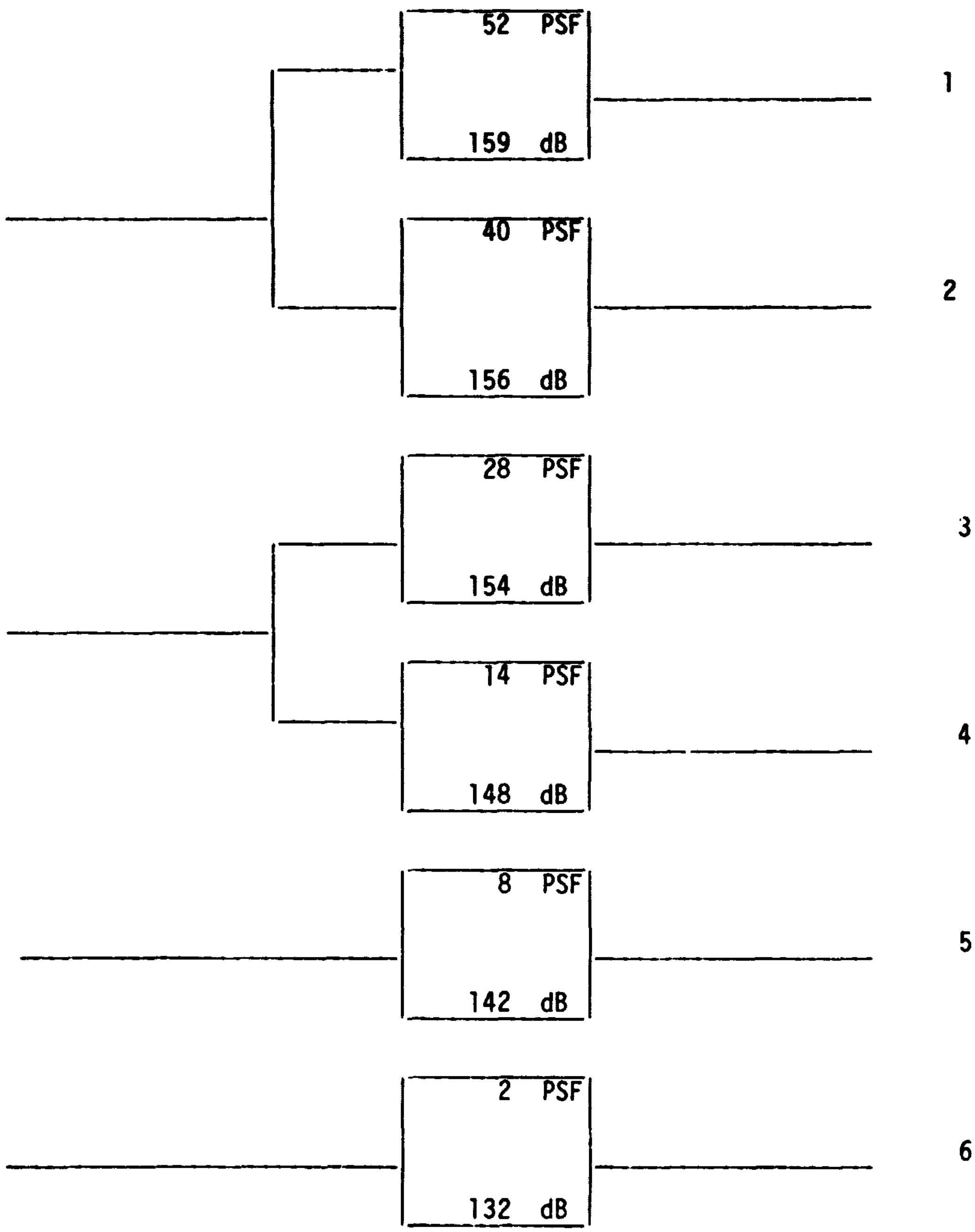
- Recorders continue to run till sonic boom coordinator gives "Recorders off" command.

Pressure Level Assignment

STATION - 1

PREDICTED OVERPRESSURE 16 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL



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CALIBRATION AND OVERPRESSURE SETTINGS

CONSOLE 1 DATE ______

STATION 1 OPERATOR Bill Graveline/Bob Edahl

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS: D.G ATTN. SETTING	CAL. SETTINGS: B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS: D.G ATTN. SETTING	RUN SETTINGS: B.B. AMP. SETTING	TAPE CH
3	at		1	159 dB		1	1
			2	156 dB		2	2
4	at		3	154 dB		3	3
			4	148 dB		4	4
5	at		5	142 dB		5	5
6	at			132 dB			6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable.
Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 2

PREDICTED OVERPRESSURE 16 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL
	52 PSF 159 dB	1
	40 PSF 156 dB	2
	28 PSF 154 dB	3
	14 PSF 148 dB	4
	8 PSF 142 dB	5
	2 PSF 132 dB	6
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CALIBRATION AND OVERPRESSURE SETTINGS

CONSOLE 2 DATE ______

STATION 2 OPERATOR Shirley Grice

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS: D.G ATTN. SETTING	CAL. SETTINGS: B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS: D.G ATTN. SETTING	RUN SETTINGS: B.B. AMP. SETTING	TAPE CH
7	___ at ___	____	1 ____	159 dB	____	1 ____	1
			2 ____	156 dB		2 ____	2
8	___ at ___	____	3 ____	154 dB	____	3 ____	3
			4 ____	148 dB		4 ____	4
9	___ at ___	____	5 ____	142 dB	____	5 ____	5
10	___ at ___	____		132 dB	____		6

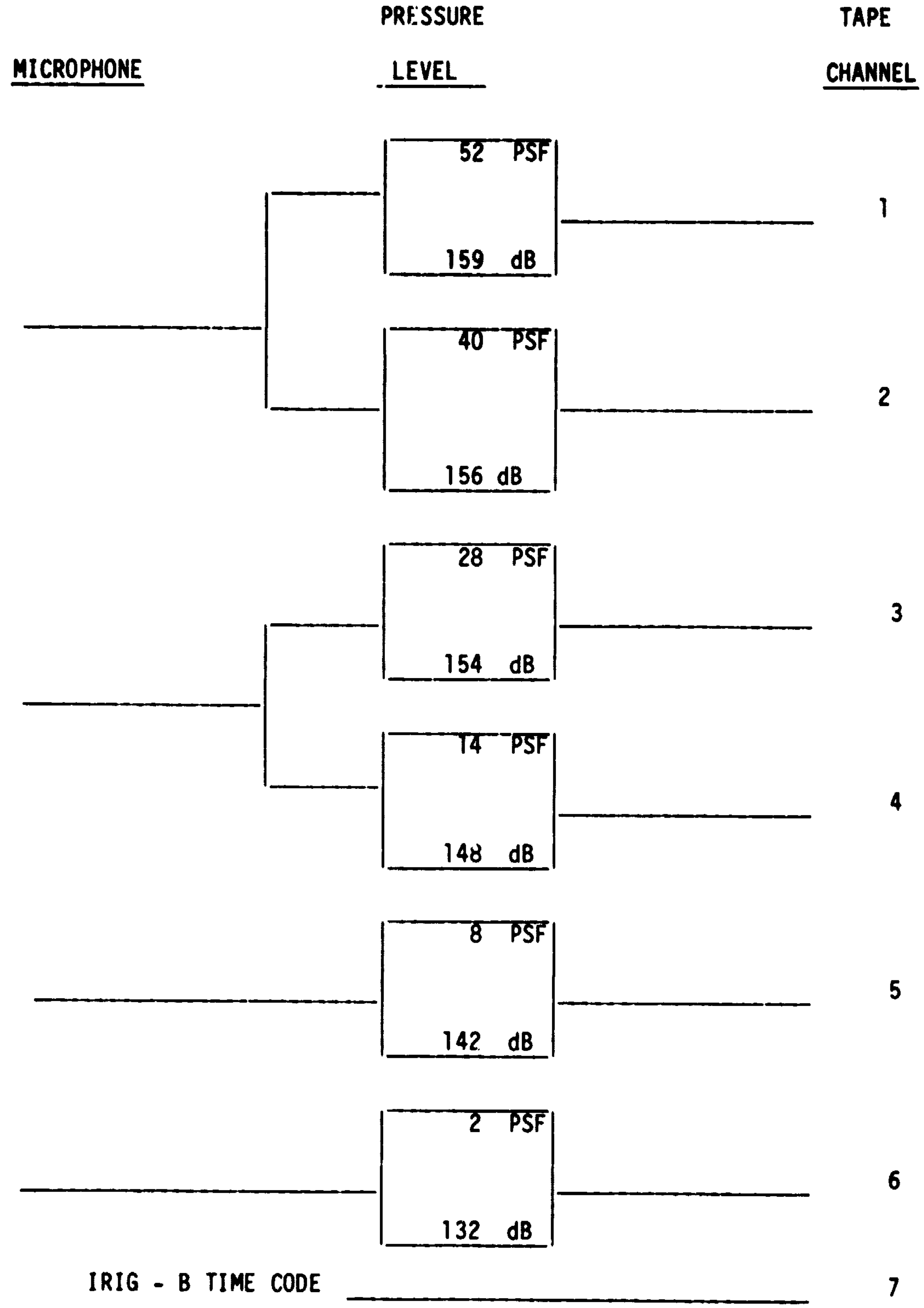
Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable.
Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 3

PREDICTED OVERPRESSURE 16 PSF (lb/ft^2)



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CALIBRATION AND OVERPRESSURE SETTINGS

CONSOLE 3 DATE

STATION 3 OPERATOR Capt. Elizabeth Ayers

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS: D.G ATTN. SETTING	CAL. SETTINGS: B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS: D.G ATTN. SETTING	RUN SETTINGS: B.B. AMP. SETTING	TAPE CH
11	___ at ___	___	1 ___	159 dB	___	1 ___	1
			2 ___	156 dB		2 ___	2
12	___ at ___	___	3 ___	154 dB	___	3 ___	3
			4 ___	148 dB		4 ___	4
13	___ at ___	___	5 ___	142 dB	___	5 ___	5
14	___ at ___	___		132 dB	___		6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 4

PREDICTED OVERPRESSURE 16 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL
	52 PSF / 159 dB	1
	40 PSF / 156 dB	2
	28 PSF / 154 dB	3
	14 PSF / 148 dB	4
	8 PSF / 142 dB	5
	2 PSF / 132 dB	6

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CALIBRATION AND OVERPRESSURE SETTINGS

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CONSOLE 4 DATE

STATION 4 OPERATOR Lt. Carolyn Jones

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS D.G ATTN. SETTING	CAL. SETTINGS B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS D.G ATTN. SETTING	RUN SETTINGS B.B. AMP. SETTING	TAPE CH
15	at		1	159 dB		1	1
			2	156 dB		2	2
16	at		3	154 dB		3	3
			4	148 dB		4	4
17	at		5	142 dB		5	5
18	at			132 dB			6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 5

PREDICTED OVERPRESSURE 8 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL
	1 PSF 124 dB	1
	2 PSF 132 dB	2
	4 PSF 138 dB	3
	8 PSF 142 dB	4
	20 PSF 150 dB	5
	26 PSF 152 dB	6
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CALIBRATION AND OVERPRESSURE SETTINGS

CONSOLE 5

DATE

STATION 5

OPERATOR Jerry Winkler

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS D.G ATTN. SETTING	CAL. SETTINGS B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS D.G ATTN. SETTING	RUN SETTINGS B.B. AMP. SETTING	TAPE CH
19	at		1	124 dB		1	1
			2	132 dB		2	2
20	at		3	138 dB		3	3
			4	142 dB		4	4
21	at		5	150 dB		5	5
22	at			152 dB			6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

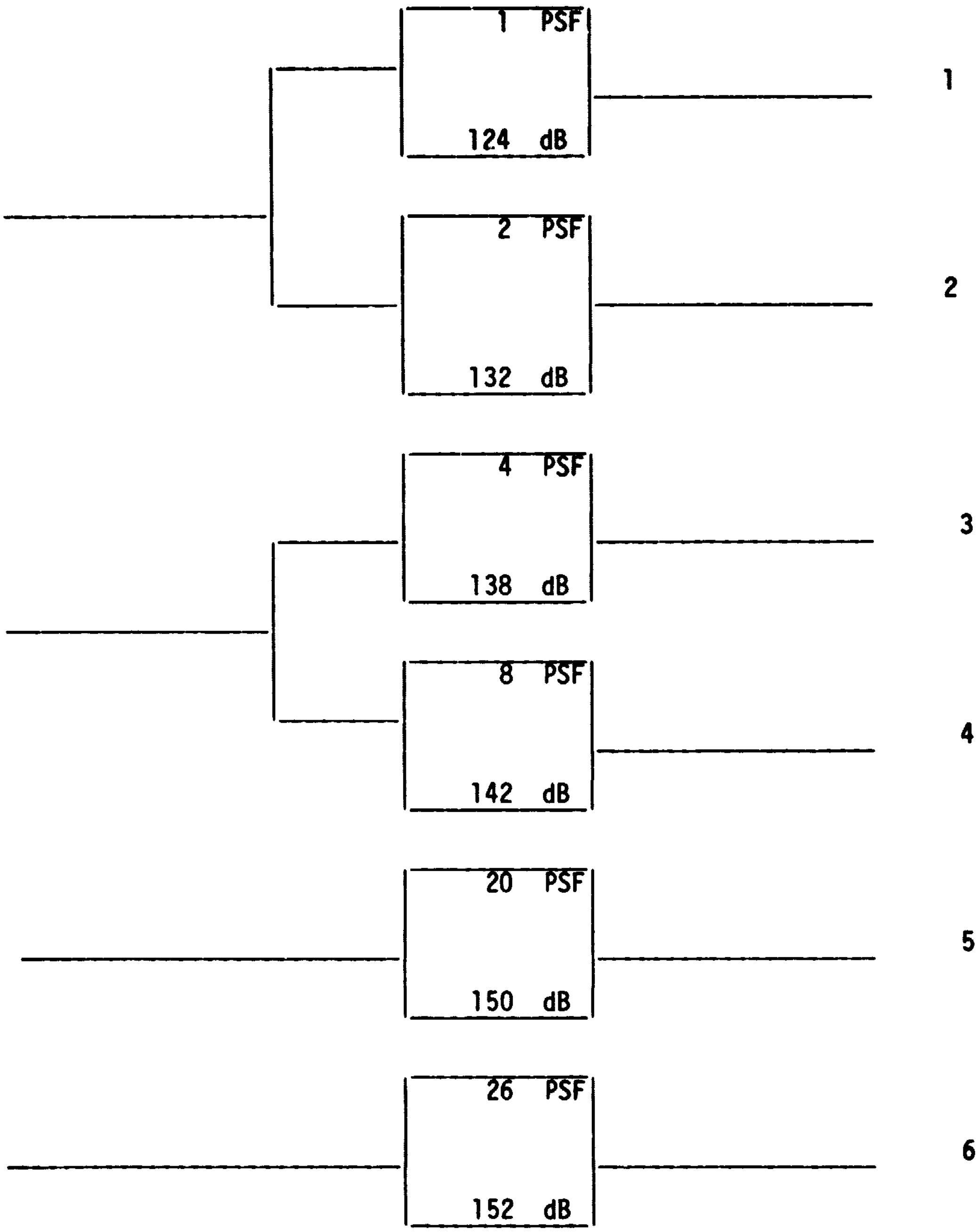
NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 6

PREDICTED OVERPRESSURE 8 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL



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CALIBRATION AND OVERPRESSURE SETTINGS

CONSOLE 6 DATE ______

STATION 6 OPERATOR Ellis Davis

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS D.G ATTN. SETTING	CAL. SETTINGS B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS D.G ATTN. SETTING	RUN SETTINGS B.B. AMP. SETTING	TAPE CH
23	___ at ___	___	1 ___	124 dB	___	1 ___	1
			2 ___	132 dB		2 ___	2
24	___ at ___	___	3 ___	138 dB	___	3 ___	3
			4 ___	142 dB		4 ___	4
25	___ at ___	___	5 ___	150 dB	___	5 ___	5
26	___ at ___	___		152 dB	___		6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

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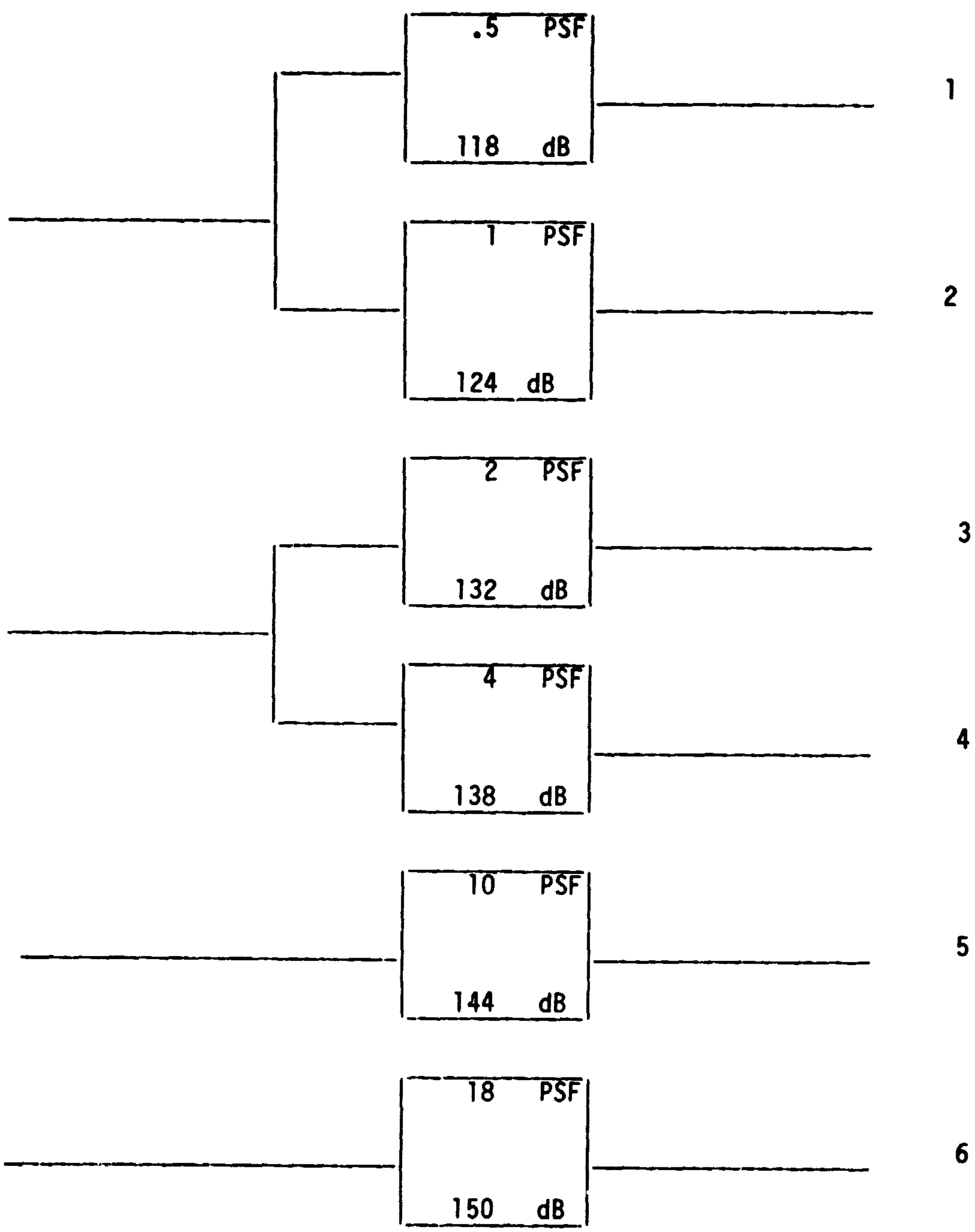
Pressure Level Assignment

STATION - 7

PREDICTED OVERPRESSURE 4 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL



IRIG - B TIME CODE 7

VOICE ANNOTATION EDGE TRACK RECORDED

CALIBRATION AND OVERPRESSURE SETTINGS

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CONSOLE 7 DATE ______

STATION 7 OPERATOR Capt. Jessie Compton

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS D.G ATTN. SETTING	CAL. SETTINGS B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS D.G ATTN. SETTING	RUN SETTINGS B.B. AMP. SETTING	TAPE CH
27	___ at ___	___	1 ___	118 dB	___	1 ___	1
			2 ___	124 dB		2 ___	2
28	___ at ___	___	3 ___	132 dB	___	3 ___	3
			4 ___	138 dB		4 ___	4
29	___ at ___	___	5 ___	144 dB	___	5 ___	5
30	___ at ___	___		150 dB	___		6

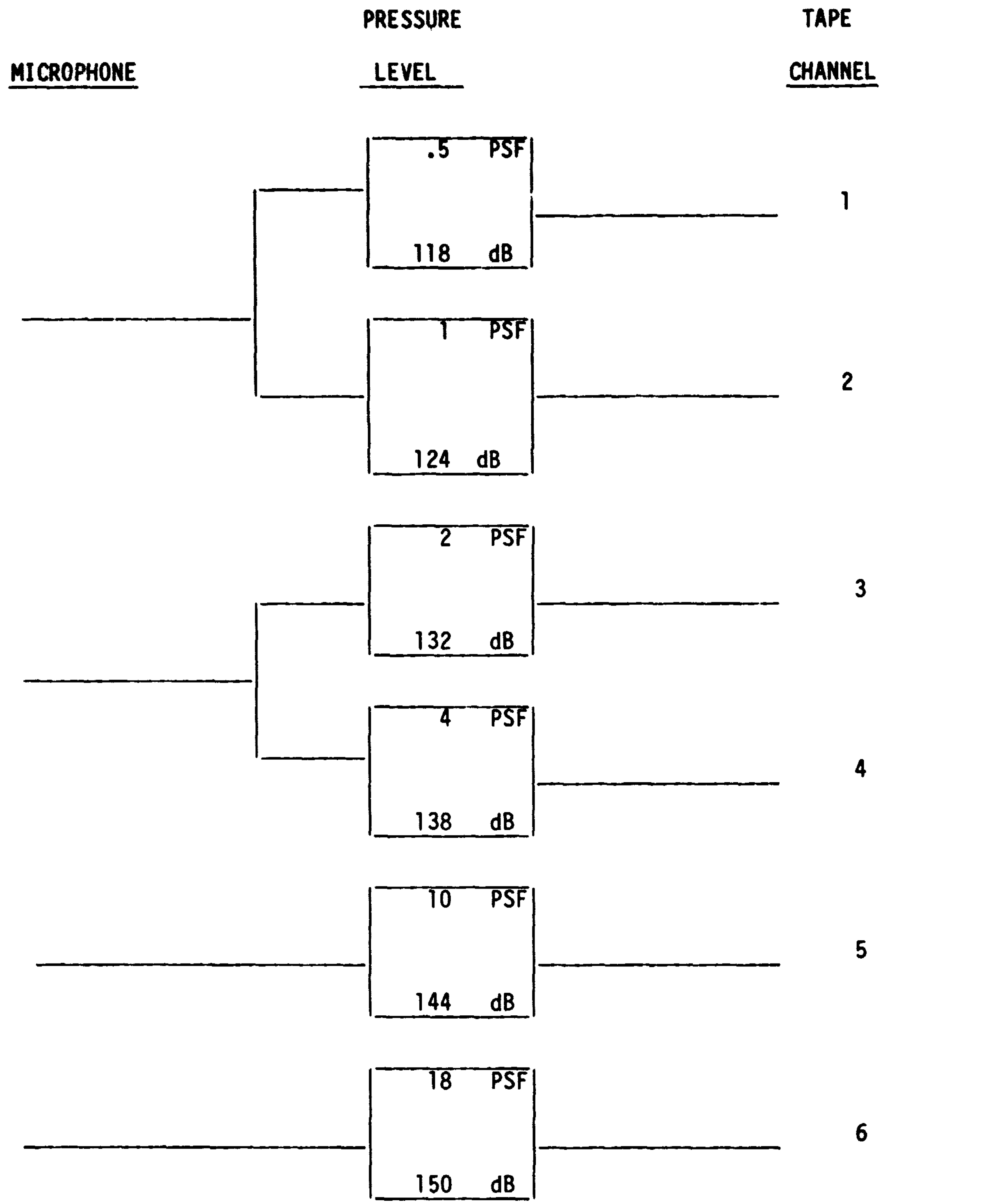
Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 8

PREDICTED OVERPRESSURE 4 PSF (lb/ft^2)



IRIG - B TIME CODE ______ 7

VOICE ANNOTATION EDGE TRACK RECORDED

CALIBRATION AND OVERPRESSURE SETTINGS

CONSOLE 8 DATE ____________

STATION 8 OPERATOR Bob Steger

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS: D.G ATTN. SETTING	CAL. SETTINGS: B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS: D.G ATTN. SETTING	RUN SETTINGS: B.B. AMP. SETTING	TAPE CH
31	___ at ___	___	1 ___	118 dB	___	1 ___	1
			2 ___	124 dB		2 ___	2
32	___ at ___	___	3 ___	132 dB	___	3 ___	3
			4 ___	138 dB		4 ___	4
33	___ at ___	___	5 ___	144 dB	___	5 ___	5
34	___ at ___	___		150 dB	___		6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 3.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

Pressure Level Assignment

STATION - 9

PREDICTED OVERPRESSURE 4 PSF (lb/ft^2)

MICROPHONE	PRESSURE LEVEL	TAPE CHANNEL
	.5 PSF / 118 dB	1
	1 PSF / 124 dB	2
	2 PSF / 132 dB	3
	4 PSF / 138 dB	4
	10 PSF / 144 dB	5
	18 PSF / 150 dB	6
IRIG - B TIME CODE		7

VOICE ANNOTATION EDGE TRACK RECORDED

CALIBRATION AND OVERPRESSURE SETTINGS

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CONSOLE 9 DATE ____

STATION 9 OPERATOR Pete Chilcott

SYSTEM NUMBER	D.G TUNES	CAL. SETTINGS D.G ATTN. SETTING	CAL. SETTINGS B.B. AMP. SETTING	ASSIGNED RUN LEVELS	RUN SETTINGS D.G ATTN. SETTING	RUN SETTINGS B.B. AMP. SETTING	TAPE CH
35	__ at __	____	1 ____	118 dB	____	1 ____	1
			2 ____	124 dB		2 ____	2
36	__ at __	____	3 ____	132 dB	____	3 ____	3
			4 ____	138 dB		4 ____	4
37	__ at __	____	5 ____	144 dB	____	5 ____	5
38	__ at __	____		150 dB	____		6

Cal. Level 130 dB, set system gain for 2 vpp input to tape recorder.

NOTE: D.G attn. setting must satisfy 2 B.B. amp settings where applicable. Avoid setting D.G attn. below 6 dB if possible.

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Table 1.- Calculated Sonic Boom Overpressures for STS-5 Lateral Measurement Stations East of the Launch Site

STATION NUMBER	BOAT NAME	LATERAL DISTANCE OF STATION FROM GROUND TRACK (N MI)	FLIGHT MACH NUMBER	FLIGHT ALTITUDE (ft)	$\Delta p_{calc.}$*
1	SUNSCAPE	6.5 SOUTH	3.5	104600	16
2	NASA-LCU	6.5 SOUTH	3.5	104600	16
3	NASA-TUG	6.5 SOUTH	3.5	104600	16
4	"TBA"	6.5 SOUTH	3.5	104600	16
5	CONTESSA	26.5 SOUTH	3.73	116200	8
6	DERBY	26.5 SOUTH	3.73	116200	8
7	VENTURE	45 SOUTH	3.84	128700	4
8	MOM'S WORRY	45 SOUTH	3.84	128700	4
9		45 SOUTH	3.84	128700	4

*Calculated nominal value at the focus, assuming a focus factor of 2.

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Table 2.- Positioning Information for the Nine STS-5 Sonic Boom Measuring Stations in the Atlantic Ocean Down Range from the Launch Site

STATION, NO./BOAT NAME	LONGITUDE,* DEG, W	LATITUDE,* DEG, N
1 SUNSCAPE	79.926	28.505
2 NASA-LCU	79.888	28.505
3 NASA-TUG	79.850	28.505
4 "TBA"	79.755	28.505
5 CONTESSA	79.782	28.172
6 DERBY	79.744	27.172
7 VENTURE	79.667	27.865
8 MOM'S WORRY	79.648	27.865
9	79.629	27.865

* Geodetic positioning information based on cycle two trajectory data

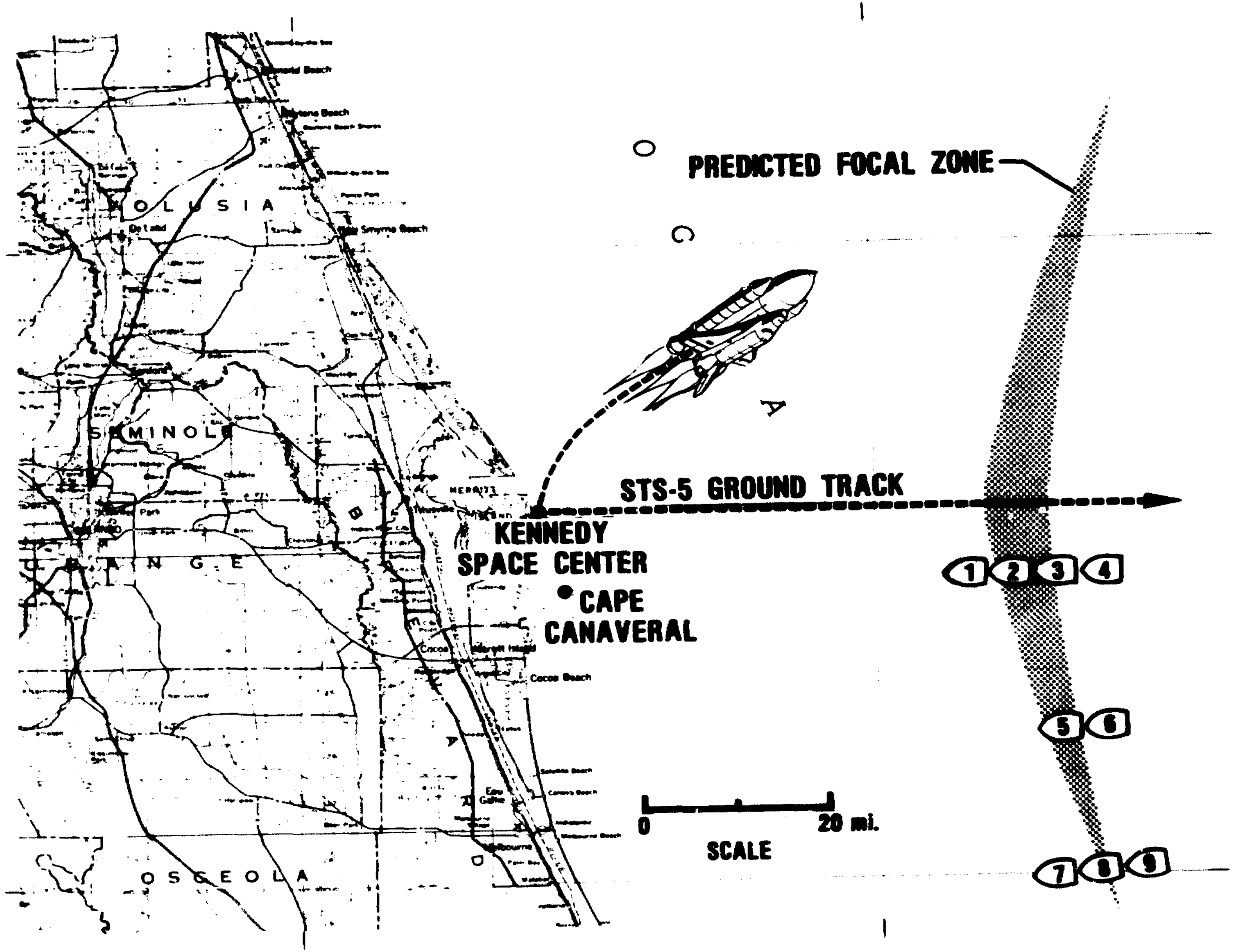

Figure 1. - Map of launch area showing positions of the nine measurement boats along with STS-5 ground track and expected region of sonic boom focusing.

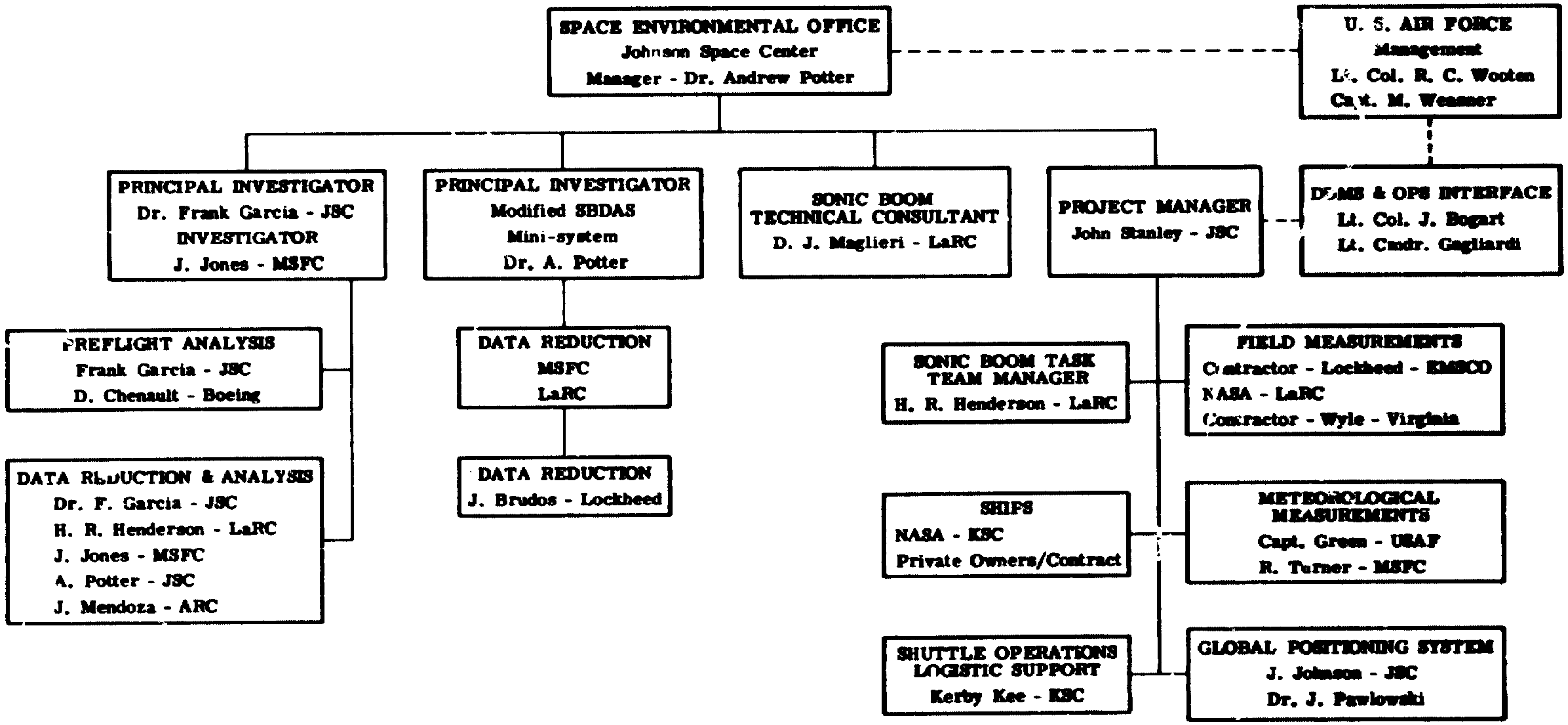

Figure 2. - Program responsibilities.

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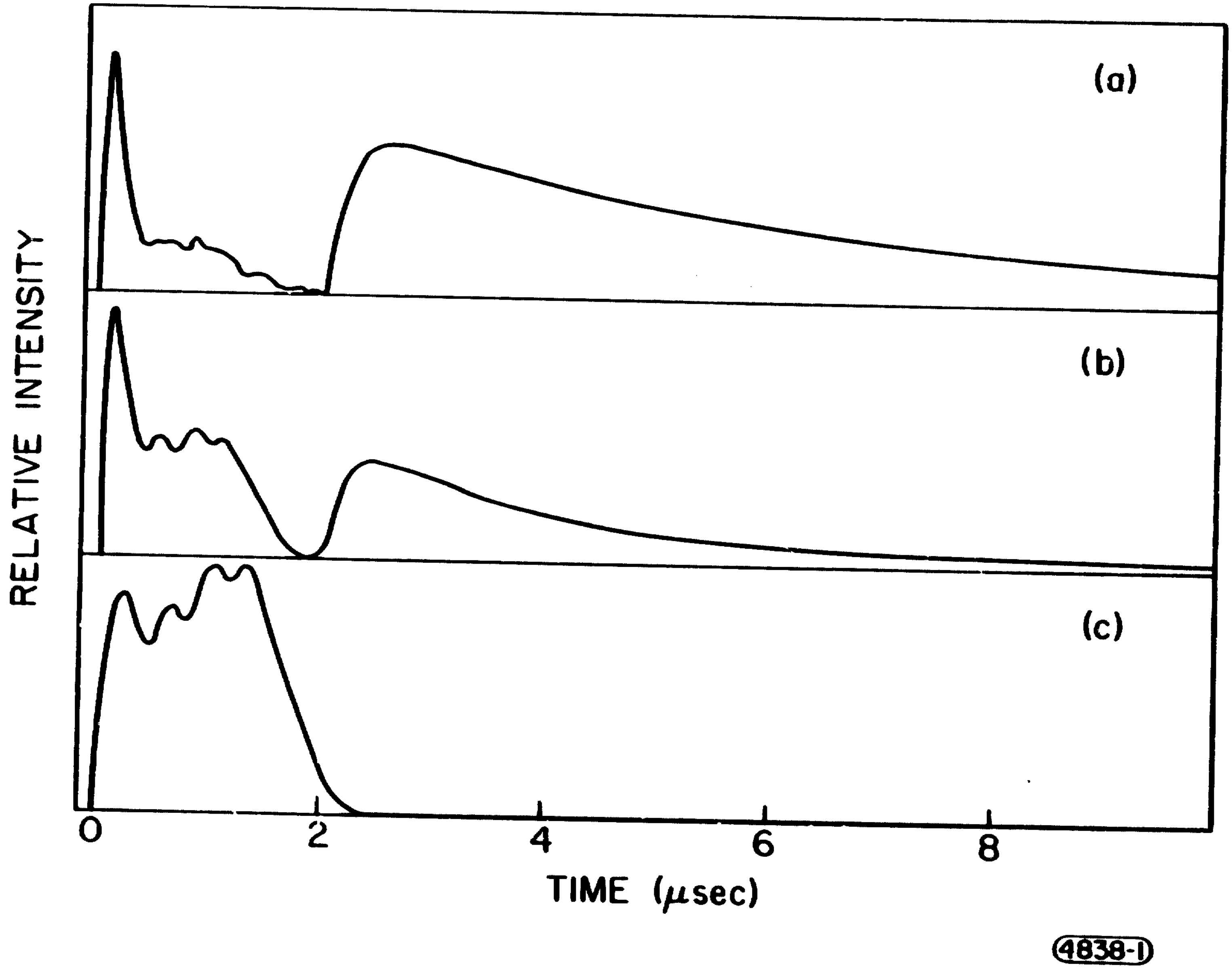

Fig. 7--Temporal behavior of microwave discharge emission. (a) Anti-Stokes output at 550 Å, (b) resonance line emission at 584 Å, and (c) input microwave pulse.

~ 2 μs. Thus, the ratio of anti-Stokes intensity to resonance line intensity was largest in this recombination tail.

Unfortunately, operation late in the recombination period has a serious disadvantage. The measured widths of absorption features in potassium were about 2.5 cm^{-1} wider than measurements of the same features made during the avalanche period. We believe that this is due to an increase in the temperature of the metastables and hence, a larger Doppler width during the recombination period. The most likely mechanism for this heating is the elastic collisions of neutrals and ions with hot electrons, and the subsequent formation of hot metastables during the recombination period. From linewidth measurements during the recombination period we estimate that the Doppler width is 3.5 cm^{-1}, which implies an atomic kinetic temperature of ~ $3000^{o}K$ (0.26 eV). The spectral width of the anti-Stokes radiation during the avalanche period was confirmed to be equal to that obtained with the hollow cathode discharge by measuring the linewidths of the same potassium absorption features. Because of this effect, all the measurements and spectra reported were made during the avalanche period.

Using the microwave discharge we extended the spectral region examined in potassium to 536.8 Å - 558.4 Å, as shown in Table 4. To achieve a signal-to-noise ratio of 3 to 1 with an integration of 50 laser pulses per point, a minimum of ~ 1 mJ of laser energy per pulse was required. Commercial sources of such energy per pulse are available to at least 2 μm, which implies a possible XUV spectral range of ~ 537 Å - 584 Å.

Table 5 lists a number of additional potassium absorption features we observed using the microwave excited discharge; all have been previously observed by Mansfield [16]. Typical absorption scans are shown in Fig. 8, which are computer generated plots containing 1024 points corresponding to laser