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LANGLEY RESEARCH CENTER METROLOGY PROGRAM STATUS FOR FISCAL YEAR 1987

Frederick A. Kern

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Langley Research Center
Hampton, Virginia 23665

SUMMARY

The status of the Langley Research Center's metrology program for fiscal year 1987 is presented. The NASA Metrology Information System, which was operational for the entire year, provided the majority of performance data describing work analysis, turnaround time, out-of-tolerance instrument data, and other instrument service data. Calibration system development, equipment replacement and updating, status of last year's planned objectives, and Reference Standard certification requirements are described. The status of the LaRC voltage and resistance measurement assurance program and the agency-wide resistance program is reviewed. Progress on fiscal year 1987 objectives is discussed and fiscal year 1988 objectives are stated.

METROLOGY PROGRAM OVERVIEW

The functional organization for the LaRC metrology program is shown in figure 1. Metrology and calibration is a quality assurance function of the Systems, Safety, Quality, and Reliability Division under the Director for Systems Engineering and Operations. The Head of the Pressure and Flow Measurement Section of the Instrument Research Division has been delegated the Metrology Program Manager responsibilities to develop and direct the program. The Langley Research Center metrology program has operated in fiscal 1987 with seven organizations, both civil servant and contractor, providing instrument calibration and repair services. The Instrument Research Division, supported by its support service contractors, Wyle Laboratories and Modern Machine and Tool, provides calibration, repair, and application services for the broad spectrum of research instrumentation used by LaRC's wind tunnels and research laboratories. This contractor support also covers new instrument acceptance testing and digital system maintenance and applications. The Fabrication Division's Quality Assurance and Inspection Office is responsible for the calibration of dimensional instruments and artifacts used in their inspection of machine shop manufactured hardware. The Operations Support Division's Component Verification Facility provides pressure vessel certification testing, pressure fitting and hose manufacturing, pressure control valve testing, and calibration of pressure instrumentation required in the operation of wind tunnels and research facilities. The Operations Support Division utilizes their support services contractor, RCA, to provide calibration and maintenance for industrial equipment including controls, recorder systems, gages, gas detectors, closed circuit video systems, and audio systems. Wyle Laboratories, under another contract , provides support for operating the National Transonic Facility, a cryogenic wind tunnel.

A segment of this Wyle effort requires the calibration and maintenance of the oxygen gas level monitoring systems used in this tunnel and in the 0.3-meter transonic cryogenic tunnel to ensure safety of operating personnel. Each of these organizations utilize the Center's metrology program calibration labels. Currently all of these organizations except for the RCA support service effort are participating in the NASA Metrology Information System (NMIS). RCA is expected to begin utilizing NMIS in 1988.

A major improvement in the calibration recall program in fiscal year 1987 was accomplished by bringing Center management into the program operation. Under the previous recall program, property custodians and users were notified monthly of instruments due and overdue for calibration. Response to these notices ran typically about 75 percent. In the current program, specified by LHB 5330.9--Langley Research Center (LaRC) Metrology Program, there are now two more specific actions that can be taken in cases of failure to respond to notices. The sequence is: (1) the Metrology Control Center notifies cognizant property custodians of instruments due for calibration 30 days in advance using NMIS; (2) the Metrology Program Manager notifies cognizant property custodians of instruments overdue in excess of 30 days; (3) the Metrology Program Manager notifies the cognizant Division Chief of instruments overdue in excess of 60 days; and (4) the Metrology Program Manager notifies the cognizant Director-for of instruments overdue in excess of 90 days. The implementation of this overdue instrument follow-up procedure has been very successful with 100 percent compliance at the 90-day overdue level.

LaRC utilizes the National Bureau of Standards (NBS) Measurement Assurance Program (MAP) in the voltage and resistance measurement disciplines to establish traceability to national standards. It is currently planned to perform a MAP set every 2 years. The volt MAP performed in 1986 was not valid since the voltage standard lost power during return to NBS; therefore, it was performed again in 1987. Five MAP's have been completed with NBS (figure 2). For resistance, three MAP's have been completed for both the 1-ohm and 10,000-ohm standards. (figs. 3 and 4).

LaRC has continued to develop the NASA resistance MAP to provide traceability to all NASA installations. During 1987, LeRC, ARC, and WSTF completed MAP's for the 1-ohm and 10,000-ohm standards. Because of the time required for each installation to complete a MAP, a second set of resistors has been purchased to establish western and eastern United States MAP's to allow each installation the opportunity to obtain correlation each year. It is recommended that the NASA Metrology and Calibration Workshop develop a handbook establishing the procedure to control this effort and maintain an acceptable schedule.

The Field Electronics and Laboratory Instrument Calibration System (FELICS), LaRC's mobile instrument service system, continues to be a productive element of the calibration program. In fiscal year 1987, instruments in 13 facilities were

serviced. A total of 1,109 instruments were calibrated requiring 1,691.2 hours, which results in an average of 1.64 hours per instrument. This average is less than the 2.12 hours per instrument average of fiscal year 1986. The use of this capability has increased to the saturation level and it will be extremely difficult to service additional facilities, particularly those with large instrument populations. In addition, some facilities are requesting service twice per year. As a result, the design of an upgraded mobile calibration facility is planned for fiscal year 1988. Procurement of this new mobile system will depend on the availability of funds.

NASA METROLOGY INFORMATION SYSTEM

NMIS has been in operation at LaRC since May 1986. The procedures for utilizing NMIS in the day-to-day operations are continually being refined to minimize the workload impact on the overall metrology and calibration process. Training is very important to ensure accuracy of the NMIS data base being gathered and success in interpreting the output of the system to achieve improvements in metrology and calibration operations. Two specific elements must be defined when NMIS is placed in a production status. The first is to establish the NMIS operation interval (calendar year, fiscal year, or other) and schedule the end-of-year close-out and maintenance dates. The second is to establish fixed dates for all automatically scheduled reports to ensure continuity in the reports throughout the year and from year to year. LaRC is operating NMIS on a fiscal year basis. One of the challenges we are currently facing is to interpret the NMIS output and use the information to improve the metrology program operation.

The scope of the NMIS workload in terms of transactions performed is shown in table 1. Currently, LaRC is averaging over 5,000 NMIS transactions per month. For the NMIS operation at LaRC, one person has been identified to schedule NMIS reports. This should help prevent overloading the overnight processing caused by several people scheduling reports for the same night.

STAFFING

The civil servant effort this past year is divided into several catagories. The measurement system development and LaRC Metrology Program Management required 1.9 staff years based on 2016 hours per staff year. Contract monitoring required 3.8 staff years. Instrument calibration and repair required 4.0 staff years. The total of 9.7 staff years is 2.1 staff years less than fiscal year 1986 and is primarily due to transfers and retirements without replacement. The contract effort for the four support service contractors was

41.4 staff years which also included maintenance of approximately 2,300 items of government-furnished equipment.

WORKLOAD BY MEASUREMENT DISCIPLINE

The total number of jobs by measurement discipline and the total number of calibration hours, repair hours, and service hours is shown in table 2. This data covers the period of January 1, 1987, through September 30, 1987, only and does not reflect the entire fiscal year production. The major areas of work are in pressure and vacuum (Code B), electrical (Code E), computer and computer peripheral (Codes P and Q), oscilloscopes, waveform, video and communications (Code K), and electromechanical (Code W). This data includes work from the seven performing organizations at the Langley Research Center.

WORKLOAD BY ACTION TAKEN

The workload for fiscal year 1987 is illustrated in table 3. The major efforts for the past year are acceptance testing (Code A), calibration (Code C), repair (Code R), repaired and calibrated (Code T), adjusted and calibrated (Code Q), and user acceptance (Code E). This user acceptance category is monitored closely to determine if contractor capability is being maintained or if a new capability is necessary to meet newer, advanced instrument requirements. Several types of items are not acceptance tested. Examples of these are video monitors and handheld calculators.

TURNAROUND TIME

Turnaround time was measured for the major support service contractor providing instrument calibration and repairs. The turnaround time is measured in three categories; 1-4 days, 5-14 days, and over 15 days. The data are illustrated by fiscal year quarter in table 4 and indicates 12.38 percent for the 1-4 day class, 65.76 percent for the 5-14 day class, and 21.47 percent for the over-15-day class. The sample size for this data is 15,335 instruments. In general the workload remained stable except for the July through September period which showed an increase in the 1-4 day class of nearly a factor of two. This is attributed to a large increase in delivery of new instruments and personal computers requiring acceptance testing.

OUT-OF-TOLERANCE AND INOPERATIVE INSTRUMENTS

Reports for 5 monthly periods for out-of-tolerance and inoperative instruments were obtained from NMIS. This data for the six NMIS condition codes is shown in table 5. In general the total number of instruments in these six categories declined over the April through October period. Also shown are the total number of instruments completed for each month. A simple calculation shows the percentage of out-of-tolerance and inoperative instruments which ranged from a high of 24 percent to a low of 15 percent for the period. The total number of instruments completed includes the new instruments which were acceptance tested. Subtracting that monthly number from each month's total and comparing to the out-of-tolerance numbers indicates a range with a high of 45 percent to a low of 28 percent. These numbers more closely reflect the condition of instruments received in the calibration labs after being used in the LaRC facilities and laboratories.

NMIS DATA BASE

As of September 30, 1987, NMIS contains 42,015 items. The reason for this large data base was that during conversion to NMIS, it was possible for the Metrology Control Center to identify all of the instruments in NEMS that would be included in NMIS. In addition, the items identified by the Metrology Control Number contained in the old recall system were added to the NMIS data base. During this past year, there were 671 noncontrolled instruments added to NMIS (01 transaction), 5,942 controlled instruments added (02 transaction), and 134 instruments deleted from NMIS (68 and 69 transactions).

CALIBRATION SYSTEM DEVELOPMENT

No signficant advances were achieved in calibration system development in fiscal year 1987. However, it was decided to initiate the use of personal computers for automated calibration system control and data acquisition and analysis instead of the desk top calculators used successfully for the past 13 years. Seven AT style personal computers having 20 megabyte hard disks and IEEE communication cards have been purchased for use by one of the support service contractors. The personal computers are significantly less expensive than the calculators.

A system design has been completed to transfer pressure transducer calibration data from the central calibration laboratory to one wind tunnel using floppy disks. Hard copy calibration data will be maintained in addition to the floppy disk. This effort has the ultimate potential to transmit calibration data

electronically, mass store the data and eliminate calibration data sheets. The floppy disk segment of this effort is planned to be implemented by September 1988.

EQUIPMENT REPLACEMENT AND UPDATING

A significant effort was made to support a budget augmentation request for institutional equipment modernization. This activity is being led by the Director, Supply and Equipment Management Office, Code NIE, NASA Headquarters. Our request for $8.8 million consisted of $6.9 million for centralized loan pool instrumentation and $1.75 million for 11 calibration systems (table 6). Code NIE has made presentations to the Headquarters institutional program offices, the comptroller, the Deputy Associate Administration for Management, and the Institutional Management Council. The request has been presented to the Strategic Planning Council and the Administrator by a Deputy Associate administrator. Based on these reviews, followup justifications and photographs have been provided for future justification efforts.

Two major pieces of equipment were purchased at the end of the fiscal year for improvements in thermal radiation calibration and model angle-of-attack sensor calibration. A two-degree of freedom angle-of-attack accelerometer calibration system will replace the existing single axis system. This new system will simulate the facility measurement environment for precision angular measurement equipment and angle-of-attack (AOA) accelerometers. This system will be computer-controlled for both precision instrument positioning and data acquisition. The calibration measurement uncertainty requirements of 5 arc seconds over a 180° range in each axis compares with current single axis requirement. This system costs approximately $85,000.

An infrared camera system has been purchased for development of IR thermal scanning system calibration techniques. This personal computer-controlled system has a temperature range of -20 to 800 °C with expansion to 1500 °C using a filter. The sensitivity is 0.07 °C at a 30 °C object temperature and the thermal display has 280 lines per frame. The estimated cost is $100,000.

REFERENCE STANDARD CERTIFICATION

During fiscal year 1988, LaRC will require calibration of several of its Reference Standards by the National Bureau of Standards. These are:

Item	Manufacturer
Standard Resistor	L&N
Megohm Standard (3)	Keithley

Item	Manufacturer
Accelerometer	Kistler
Microphone	B&K
Dead Weight Tester	Ruska
Air Piston Gage	Ruska
Dead Weight Tester	D&H
Platinum Resistance Thermometer (2)	Rosemount
Shunt	Rubicon
Decade Transformer Divider	Gertsch
Dew Point Hygrometer	EG&G

In addition, one optical pyrometer will be calibrated by the National Research Council, Canada Laboratory for Basic Standards, Physics Division.

STATUS OF PLANNED ACTIVITIES FOR FY 87

Ten 1987 LaRC Metrology Program activities were outlined at the 1986 Metrology and Calibration Workshop. The current status of these activities is:

- Expansion of the NMIS to include all organizations providing instrument service - Procedures for utilizing NMIS are continually being refined. Negotiations have been initiated to bring the digital computer maintenance effort into NMIS. One support service contractor (RCA) provides approximately 1100 instrument services per year and has not yet been made part of the NMIS.

- Continuation of the NASA RMAP consisting of 1 ohm and 10K ohm artifacts - This effort has continued successfully with ARC, LeRC, and WSTF participating this past year. Turnaround time continues to be a problem and must be solved if each Center is to participate in the MAP every year.

- Completion of documentation of metrology procedures including NMIS operation for the Instrument Research Division - Continued modification of NMIS procedures has slowed completion of this project. It is estimated to be approximately 75 percent complete.

- Evaluation of fiber optic thermometer for measurements at temperatures up to 2000 °C - Purchased thermometer and currently conducting tests. Preliminary results indicate unit may be too fragile for wind tunnel use but suitable for laboratory use. Inoperative data processing cards in the personal computer impacted system evaluation. Additional testing currently underway.

- o Upgrading of IR calibration source for temperatures up to 3300 °C - Purchased thermal source. Hardware recently delivered but not yet in operation due to higher priority workload. Purchased automated Agema Model 880 IR system. Upgraded Aga Model 750 IR camera for real-time data presentation.

- o Establishment of an oxidizing atmosphere calibration capability for sensors up to 1600 °C - Oxidizing furnace purchased and placed in operation.

- o Automation of heat flux sensor calibration system - No progress due to lack of funding.

- o Development of the design and specifications for an expanded capability mobile calibration system - Worked potential funding through an augmentation funding effort led by NASA Headquarters, Code NIE. Held meetings with potential vendors to discuss requirements for the system. System specifications will be ready July 1988.

- o Definition of requirements to increase low pressure calibration capability to support LaRC wind tunnel and flight projects - Two projects, the Aeroassist Flight Experiment and NASP testing, are driving this effort. Current requirements for sensor calibration cover a range of 0.0001 to 0.5 psia with a measurement uncertainty of less than one percent of magnitude. Thermal environment extends from -135 to 250 °F. In addition, a calibration capability must be developed to perform in situ calibrations for the hypersonic wind-tunnel instrumentation. Wind-tunnel experiments to evaluate feasibility of performing high accuracy, low pressure calibrations in the wind tunnel are being performed.

- o Completion of NASA metrology catalog updating - All Center inputs received since November 1986 have been updated and mailed to the Center representatives. The updated capability charts are from ARC, JSC, KSC, LeRC, NSTL, WFF, and NSTL.

FUTURE OBJECTIVES

The LaRC Metrology Program will continue to develop through a series of planned activities involving both development of measurement techniques and systems and improvement in operational procedures. These activities are:

1. Develop performance specifications for advanced mobile automated calibration system.

2. Develop in situ automated pressure transducer calibration system for very low pressure wind-tunnel testing of NASP models.

3. Establish measurement uncertainty of two-axis AOA accelerometer and bring calibration system to operational status.

4. Develop operational procedures to bring all instrument service contractors into NMIS.

5. Develop methods to use NMIS data base to promote improvement in instrument user's attitude toward periodic instrument calibration.

6. Complete Instrument Research Division document defining the metrology and calibration system and NMIS procedures.

7. Identify and implement a minimum of one improvement in metrology program procedures to reduce hardcopy paper work.

8. Review LaRC Metrology Program Handbook 5330.9 and revise as necessary.

CONCLUDING REMARKS

During fiscal year 1987, the LaRC Metrology Program has continued to improve its effectiveness. Currently, there are seven organizations, civil servant and contractor, from three LaRC Directorates providing instrument calibration and maintenance services within the program. This year Center management was brought into the program operation through the establishment of 60-day and 90-day overdue calibration reporting to the Division Chief and Director-for levels. The NASA Metrology Information System containing 42,015 instruments was operated for the entire year requiring over 61,000 transactions to process metrology system data. The total number of instrument services, as tracked by NMIS, was 22,253. LaRC continued to be the agency "NBS" for the resistance measurement area, completing the 1-ohm and 10,000-ohm measurement assurance program with ARC, LeRC, and WSTF. Eight Metrology Program objectives have been established for fiscal year 1988.

NMIS TRANSACTION		TOTAL	AVERAGE/MONTH (APPROXIMATE)
01	Receipt of Noncontrolled Items	671	56
02	Receipt of Controlled Items	5,942	495
04	Return from Record History	3	71
05	Retagging	5	71
34	To Service/Calibrate (Mass)	12,959	1,080
35	To Service/Calibrate	448	37
36	Awaiting Parts	1,442	120
37	Return from Service/Calibrate	13,285	1,107
38	Cost Update	2	71
39	Custodian Account Update	159	13
40	User Number Update	55	5
41	Instrument Location Update	92	8
44	Record Data Update	2,458	205
46	Calibration Interval Update	4,532	378
47	Factory Repair/Service	7	71
48	Recall I.D. Update	1,909	159
68	Excess	8	71
69	Remove from Active Database	126	11
	Summary File Update	3,892	325
	MCD Selection	13,479	1,123
	TOTAL	61,474	5,123

Table 1. NMIS Transactions for FY 1987

MEASUREMENT DISC CODE	MEASUREMENT DISCIPLINE	JOBS	HOURS CALIBRATION	HOURS REPAIR	HOURS SERVICE
A	Acoustics, Vibration, Shock	36	137.8	68.9	10.7
B	Pressure and Vacuum	4,477	5,757.9	5,465.0	96.5
C	Chemical and Analytical	10	33.2	9.3	0.1
D	Dimensional	127	241.7	17.2	12.6
E	Electrical/Electronic	3,423	8,975.0	5,446.9	1,140.7
F	Frequency Standards and Counters	133	568.6	174.2	15.9
G	Radiometry and Photometry	22	78.9	45.0	10.6
H	Temperature and Humidity	229	963.0	257.0	81.2
I	Ionizing Radiation	49	19.9	117.8	12.9
J	Microwave and RF	36	102.0	23.8	6.8
K	Oscilloscopes, Waveform, Video and Communications	829	3,676.4	1,984.4	251.8
L	Liquid and Gas Flow	32	173.5	13.2	4.0
M	Mass, Force, Torque	250	2,494.2	98.7	0.7
N	Gas Detection (LaRC)	125	210.0	751.6	14.2
O	Optical (LaRC)	38	14.6	26.5	61.2
P	Personal Computers (LaRC)	393	6.6	41.8	1,413.9
Q	Computer Peripheral (LaRC)	1,614	127.1	281.5	3,619.5
R	Inertial (LaRC)	68	302.0	0.0	10.6
S	Word Processor (LaRC)	28	0.0	2.6	3.6
T	Digital Tape Recorders (LaRC)	19	14.6	7.9	54.6
U	Analog Tape Recorders (LaRC)	83	189.4	245.0	51.0
V	Photographic (LaRC)	25	17.2	1,066.3	108.5
W	Electromechanical (LaRC)	669	627.8	1,517.3	1,704.1
X	Electronic (LaRC)	63	97.3	39.7	62.4
	Totals	12,778	24,828.7	17,701.6	8,748.1

Table 2. Jobs by Measurement Discipline for ECN Controlled Instruments, 1-87 through 9-87

ACTION TAKEN CODE	ACTION TAKEN	JOBS	HOURS	HOURS/JOBS
A	Acceptance Test	5,205	17,565.6	3.37
B	Special Test	27	83.4	3.09
C	Calibrated	6,010	17,073.1	2.84
D	Decontaminated-Cleaned	7	59.6	8.51
E	User Acceptance (LaRC)	1,384	1,067.2	0.77
F	Functional Check	394	1,272.0	3.23
G	Shipped for Off-Site Repair	1	2.6	2.60
H	Hold (Awaiting Parts, Manuals, etc.)	86	54.3	0.63
I	Returned to User Unserviced	109	351.1	3.22
J	Reject-Beyond Economic Repair (BER)	192	499.6	2.60
K	Reject-Shipped for Off-Site Repair	5	21.2	4.24
L	Limited Calibration	47	218.8	4.65
M	Maintenance	180	1,300.5	7.22
N	Modified	61	597.4	9.79
O	Other	110	284.6	2.59
P	Adjusted-Limited Calibration	12	55.6	4.64
Q	Adjusted-Calibrated	1,632	7,665.7	4.70
R	Repaired	4,057	19,913.4	4.91
S	Repaired-Limited Calibration	83	850.4	10.24
T	Repaired-Calibrated	1,468	12,971.6	8.84
U	Cleaned-Adjusted-Limited Calibration	13	59.6	4.58
V	Cleaned-Adjusted-Calibrated	77	249.3	3.24
W	Cleaned-Limited Calibration	4	8.9	2.22
X	Cleaned-Calibrated	82	283.9	3.46
Y	Cleaned-Repaired-Limited Calibration	3	14.6	4.86
Z	Cleaned-Repaired-Calibrated	134	480.0	3.58
1	Reject-Accepted (LaRC)	90	746.5	8.29
2	Factory Repair/Calibration (LaRC)	139	881.4	6.34
3	Calibrate-Adjust-Calibrate (LaRC)	67	425.8	6.36
4	Calibrate-Repair-Calibrate (LaRC)	82	1,118.8	14.41
5	Fabricated/Installed (LaRC)	115	3,624.8	31.52
6	Warranty Repair (LaRC)	125	492.9	3.94
7	Vendor Installation/Acceptance (LaRC)	252	72.7	0.29
	TOTALS	22,253	90,430.4	4.06

Table 3. Workload by Action Taken, 10-86 through 9-87

Interval	Oct-Dec	Jun-Mar	Apr-Jun	Jul-Sep	Overall
1-4 days	7.04%	12.05%	10.86%	19.58%	12.38%
5-14 days	73.81%	68.67%	69.49%	53.87%	66.46%
7-15 days	19.15%	19.28%	19.65%	26.55%	21.16%

Sample Size - 15,335 instruments

Table 4. Instrument Turnaround Time

NMIS CODE	4-87	5-87	8-87	9-87	10-87
B (Operative - Out-of-Tolerance 1X)	140	126	105	77	79
C (Operative - Out-of-Tolerance >1X < 2X)	27	31	33	26	17
D (Operative - Out-of-Tolerance >2X < 4X)	10	12	6	6	5
E (Operative - Out-of-Tolerance >4X)	11	7	12	9	8
F (Operative - Out-of-Tolerance - indet)	1	1	1	0	4
G (Inoperative)	74	83	80	63	74
	263	260	237	181	187
Total Completed	1282	1081	1290	1197	1120
% Out-of-Tolerance	20.5	24	18.4	15.1	16.7
Less Acceptance Instruments (%)	33.6	44.8	31.7	27.7	29.4

Table 5. Out-of-Tolerance/Inoperative Instrument Data

ITEM	ESTIMATED COST
1. Mobile Automated Calibration System	$ 250K
2. Humidity Calibration System	$ 125K
3. Vacuum Calibration System	$ 125K
4. Acoustic Sensor Calibration System	$ 90K
5. Centrifuge Calibration System	$ 150K
6. Liquid Flow Calibration System	$ 375K
7. Automated Dead Weight Tester	$ 200K
8. Heat Flux Calibration System	$ 165K
9. Air Data Calibration System	$ 50K
10. Two-degree AOA Accelerometer Calibration System	$ 125K
11. Electro-Optical Calibration System	$ 250K

Table 6. Budget Augmentation Equipment Requirements

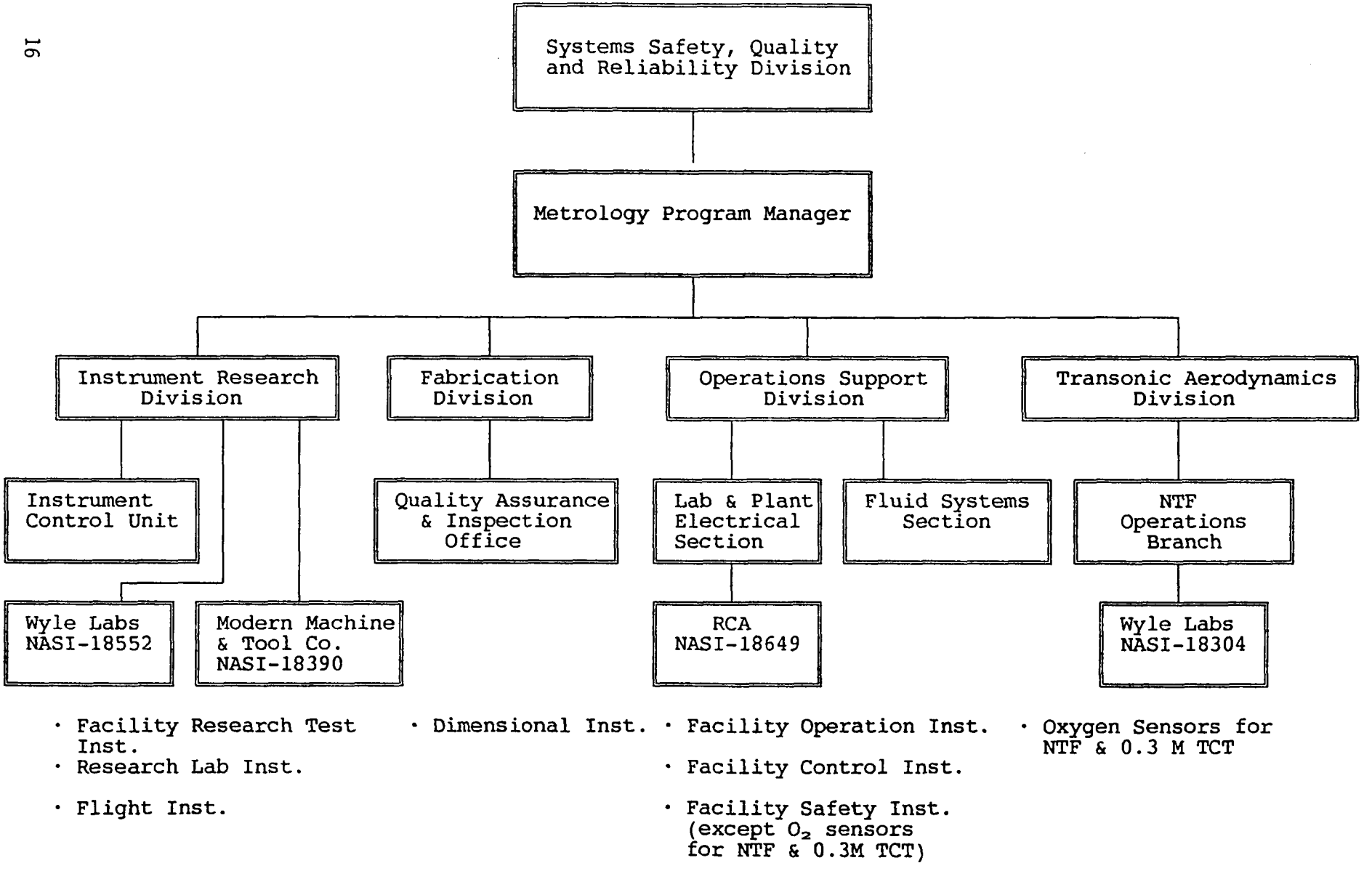

FIGURE 1. LaRC FUNCTIONAL METROLOGY ORGANIZATION AND RESPONSIBILITIES

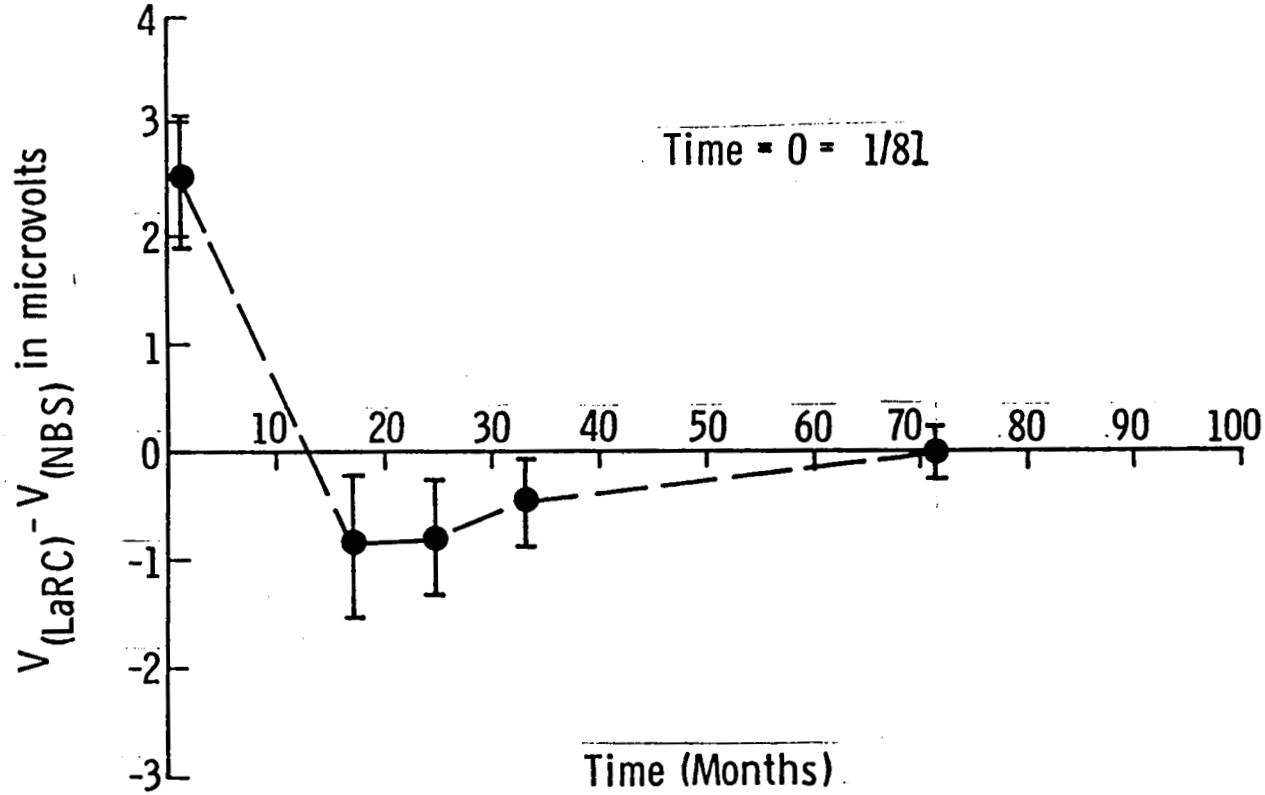

Figure 2. LaRC voltage MAP.

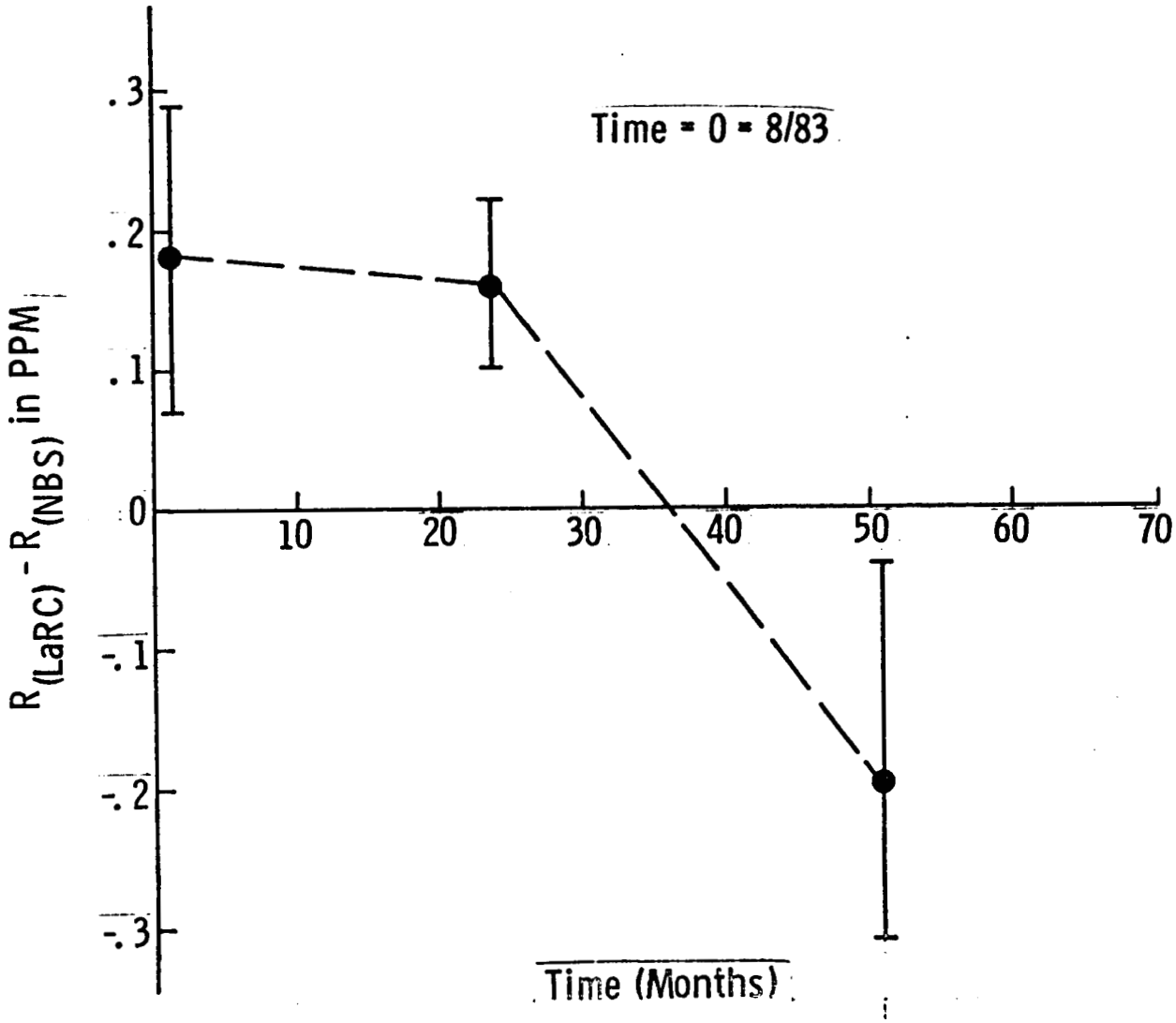

Figure 3. LaRC one-ohm resistance MAP

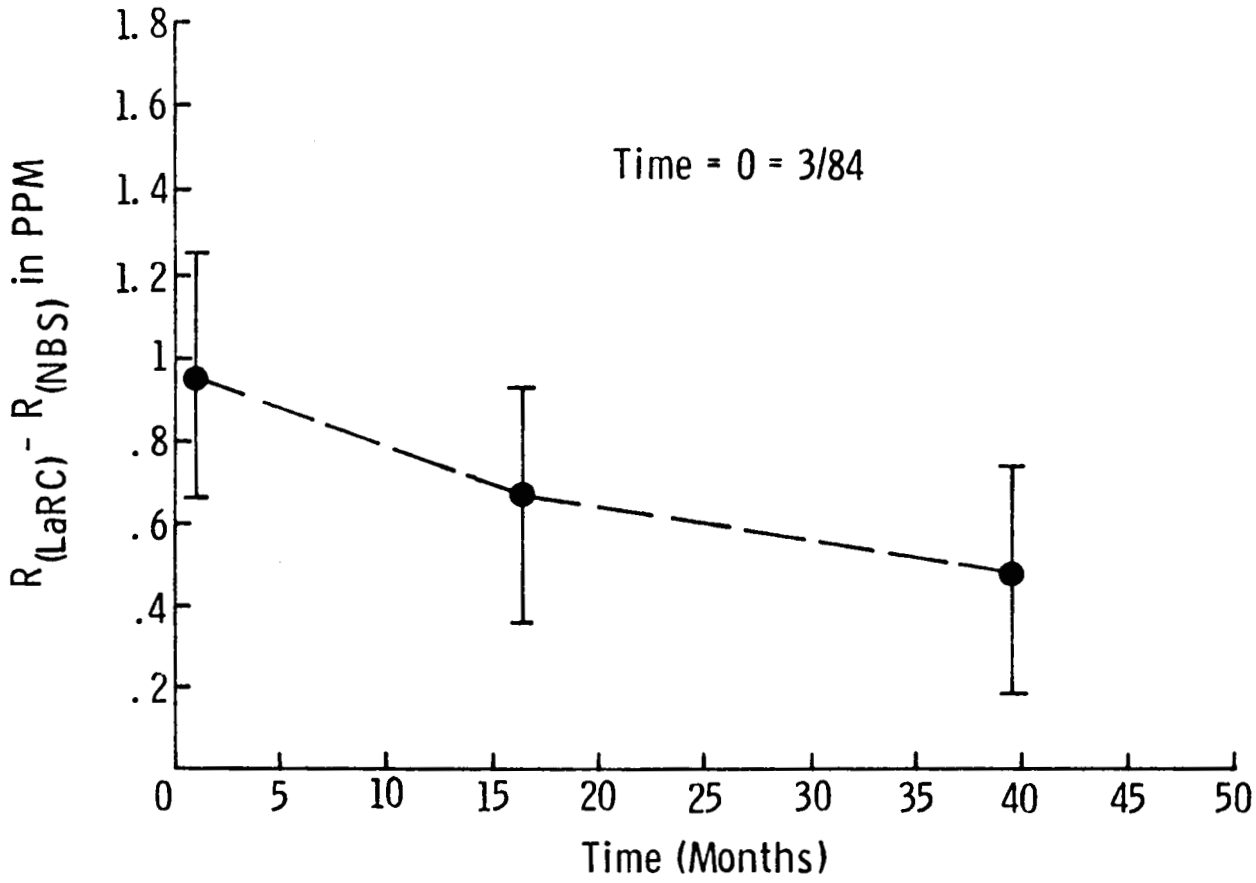

Figure 4. LaRC 10 Kohm resistance MAP

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15. Supplementary Notes

16. Abstract

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