On January 23 John Minck, Past President, Ron Kidd, Executive Vice President, and I met with Dr. Ambler, Director of the National Bureau of Standards (NBS), and key members of his staff.

The purpose of the meeting was to: (1) establish a line of communication between the new staff members and NCSL; (2) strengthen ties with old staff members; (3) relay NCSL concerns as they relate to the reorganization, the changes in calibration services, the measurement assurance, etc.; (4) become familiar with more of the reorganization details and the possible impact upon NCSL-NBS relations; and (5) broaden the NCSL relationship with NBS to include areas of interest for newer members of NCSL, i.e., pharmaceutical, chemical, medical, etc.

It was not possible to go into great detail on any one of the subjects; however, some of the meeting results do stand out.

I feel the meetings were very beneficial from NCSL's point of view in that we met and established communication with Dr. Hoffman and Dr. Lyons, who will head the National Measurement Laboratory (NML) and the National Engineering Laboratory (NEL) respectively when the reorganization is complete. We discussed with Dr. Ambler and his staff concerns of the NCSL membership over possible reduction of research in high technology fields. Dr. Ambler emphasized that the reorganization was being done to improve, not dilute, NBS's ability to carry out its charter. Dr. Ambler also implied that work on state-of-the-art high technology projects formally carried out in the Institute for Basic Standards would not be compromised but would in fact be strengthened through reorganization. Further details of the reorganization are covered elsewhere in the Newsletter.

Other meetings included a fairly extensive review of the Standard Reference Materials program was given by Georgy Uriano. Certified Standard Reference Materials can be used to develop reference methods of analysis, to calibrate measurement systems, etc., while furnishing traceability. NCSL Member Delegates who are not familiar with this program and would like more information may obtain a copy of NBS Monograph 148, "The Role of Standard Reference Materials in Measurement Systems," by requesting one from the NCSL Secretariat.

A discussion of NBS MAP's was held with eighteen Gaithersburg and four Boulder NBS staff members representing a broad spectrum of measurement disciplines. The discussion, which covered a broad range of topics, reinforced the need for a comprehensive MAP handbook. Richard Smith, NBS Boulder, is currently working on such a document and expects to have it out by October of this year.

I feel the meetings were extremely beneficial from NCSL's point of view. They strengthened my conviction that NCSL needs to be more assertive in communicating its opinions, concerns, and needs in a more definitive fashion to NBS management, as well as others. In line with this, a Board level Measurement Science Strategy working group has been established with John Minck as the chairman. The group will establish lines of communication to disseminate NCSL's positions, as appropriate. Members wishing to participate and/or obtain more information should contact John directly.

Laurel M. Auxier
President
CONTENTS
Vol. 18, No. 1, March 1978

President's Message ............................................................... 1
Board of Directors Meeting January 1978 ................................. 3
NBS/NCSL Fellow Program ....................................................... 8
New Members of NCSL ............................................................. 9
Sponsor's Delegate Report - Status of NBS Reorganization ............ 10
National Engineering Laboratory Directory ............................... 14
National Measurement Laboratory Directory .............................. 15
U.S. National Laboratory Accreditation Programs ....................... 16
NCSL Membership Kits ............................................................ 18
Ambler Becomes Director of the National Bureau of Standards ...... 19
Report on NVLAP ........................................................................ 20
Low Frequency Electrical Measurements Seminar ...................... 20
Statement of NBS FY 1979 Budget Request .................................. 21
Quality of Precision Measurement Equipment.............................. 23
Measurement Assurance ............................................................ 25
NCSL Committee Chairmen ....................................................... 38
NCSL Board of Directors and Regions ........................................ 39
How to Join NCSL ................................................................. 40

NC SL NEWSLETTER
W. J. Anson, Editor
National Bureau of Standards, 270.02
Boulder, CO 80302
(303) 499-1000, ext. 3989
Phyllis d'Houbois, Editorial Assistant

BOARD OF REVIEWERS
Laurel Auxier
Dean Brandreth
J. Graham Cameron
Ron Kidd
John Lee
Jim Valentin

The NCSL Newsletter is published quarterly in Boulder, Colorado, by the National Conference of Standards Laboratories. It is sent to NCSL-Member Organizations and to a special listing of activities and key personnel whose work is closely related to that of NCSL. Non-NCSL member subscriptions are available for $10 per year. Extra copies of an issue may be obtained at $2.50 each. Remittances should be made directly to the NCSL Secretariat:

NC SL Secretariat
National Bureau of Standards (270.00)
Boulder, CO 80302
(303) 499-1000, ext. 3787

**Articles and other items appearing in the NEWSLETTER express the views of authors and contributors and are not necessarily those of the Editor or of the National Conference of Standards Laboratories.**
HIGHLIGHTS OF THE NC SL BOARD OF DIRECTORS MEETING
January 26 and 27, 1978
New Orleans, Louisiana

President's Report
Max Unis has been appointed Liaison Delegate to ASQC.

On behalf of the NC SL membership, Laurel Auxier has written Mr. Boyle, Department of the Army Readiness Command, requesting that we be given the opportunity to review any proposed revision to MIL-C-45662A.

A letter, over Laurel’s signature, was mailed to each appointing officer of NC SL member organizations. The letter referenced several reports of the National Measurement System study and was accompanied by copies of these reports.

On January 23, Laurel, John Mince, and Ron Kidd met with members of the Bureau of Standards for a get-acquainted meeting, primarily to discuss NC SL concerns regarding the recent Bureau reorganization and its anticipated relationship with NC SL.

Executive Vice President's Report
Before this meeting, Ron Kidd had sent out a copy of the Long-Range Plan Supplement and asked for comments and suggestions regarding its implementation. Ron indicated that he anticipated release of the Plan Supplement before the May Board meeting.

Secretary's Report
Hartwell Keith reported that fifteen new organizations have joined NC SL since the last Board meeting, two of which are from the International Region.

Treasurer’s Report
Bob Delapp distributed two Treasurer's reports: one for the first quarter of our fiscal year; and the other for the NC SL Budget for Fiscal Year October 1, 1977, through September 30, 1978. [Editor's Note: The FY 78 budget is printed at the end of this report.]

Sponsor's Delegate Report
Bascom Birmingham reported on the status of the NBS reorganization. April 9, 1978, is the anticipated date for this reorganization to be officially in effect. [Editor's Note: A copy of Mr. Birmingham’s report is printed following this section.]

Secretariat’s Report
The Secretariat’s records show a membership of 333 as of January 20, 1978. Approximately 155 members of NC SL have paid their 1978 dues.

Report of Vice President - Administration

Honors and Awards Committee
Chairman Doug Doli reported that a certificate was presented to Barney Anderson for his outstanding job as chairman of the Biomedical Electrical Safety Standards Committee.

Meetings and Programs Committee
Chairman Sam Davidson reported on the status of the 1978 NC SL Workshop and Symposium Conference. Mailing dates for the first announcement will be about February 15; the first registration package will be sent around June 15; and the final brochure will be sent about August 15, 1978. Dr. Ernest Ambler has agreed to serve as Workshop and Symposium Keynote speaker.

Education and Training Committee
Chairman Hank Daniels’s letter addressed these subjects: (1) the development of a curriculum guide for metrologists; (2) the collection of course announcements into a course register; and (3) the microfilming of training materials to make the documents more manageable and to make this material a part of the NC SL Training Library.

Report of Vice President – Measurement Requirements
Vice President Graham Cameron indicated that he had found the Final Summary Report and Economic Analysis of the National Measurement System an enlightening and beneficial document. Upon his recommendation copies will be distributed to the appointing officers of NC SL member organizations.
National Measurement Requirements Committee

Chairman Frank Flynn will be circulating a questionnaire to NCSL members. The questionnaire is intended to provide a general view of the NCSL membership's current and future requirements for NBS services.

Laboratory Evaluation Committee

Chairman Dennis Gallagher reported on MIL-C-45662A and NVLAP. Drafts of a revised MIL-C-45662A are currently being reviewed by Mr. John Boyle in DoD. NCSL is to have an opportunity to comment on a later draft.

Laboratory Accreditation activities were reviewed in detail including the announcement of the establishment of a criteria committee to develop and recommend accreditation criteria for thermal insulation materials. Persons desiring to serve on this committee should contact Dr. Howard Forman, Deputy Assistant Secretary of Product Standards, Room 3876, U.S. Department of Commerce, Washington, D.C. 20230.

Dennis also reported on a meeting which he attended in Washington, D.C., on behalf of NCSL, on the subject of accreditation. This was a debriefing session on the October International meeting held in Copenhagen, attended by representatives of 17 countries and 3 international organizations.

Biomedical Safety Standards Committee

Geron Smith reporting for Chairman Andy Dickson indicated that the committee is planning to hold its next meeting in Seattle, coincident with the coming BOD meeting.

Report of Vice President - Laboratory Management and Operations

Calibration Systems Management Committee

George Rice, chairman, distributed the draft of the first of a series of survey questionnaires. The results of this survey dealing with calibration intervals will be published in the Newsletter when completed.

Measurement Assurance Committee

Gary Davidson, chairman, reported that the reconstituted committee is now complete, membership being composed of members from each national region and from NBS. Norm Belecki, NBS, indicated that NBS personnel would be available to attend regional NCSL meetings to explain the Measurement Group MAP concept. Both dimensional and AC-DC group MAP's are being planned.

Region 5 indicated sufficient interest at its December meeting to consider a Measurement Assurance Group this year. At that meeting Laurel described MAP and reported on activities of the Measurement Assurance Committee. Region 7 held a Measurement Assurance meeting on December 21, with representatives from 21 companies in attendance. Woody Eicke, NBS, attended to inform the group on current MAP activities. One group was formed and another will probably be formed. Region 8's December 8 Measurement Assurance meeting resulted in the formation of a new group, with a second group also probably being formed.

Brian Belanger reported to the Board on the Bureau's preparation of a MAP Handbook and the intent and content of the publication. A first draft by this coming fall is anticipated. A short discussion by the Board followed, wherein MAP and Round Robin measurement programs were compared, and aspects of each were discussed.

Product Design and Specifications Committee

A letter report from Chairman Chuck Corbridge reported that the committee has input comments to the RP-3 revision as well as input definitions for a Standard Glossary of Terms for a Recommended Practice for instrument specifications. Chuck reports that some influence is being felt from marketing and sales people on the PDS Committee—a healthy factor in gaining a broader view of specifications problems.

Calibration Laboratory Automation Committee

Pete England, chairman, is serving as the NCSL representative on the Industry/Joint Services Automatic Test Project.

At the recent two-day organizational meeting in Arlington, Virginia, the group's goal was stated as follows:

"To develop specific recommendations that impact automatic test measuring and diagnosis equipment calibration policies and practices to improve operational readiness and lower life-cycle costs while maintaining or improving ATE measuring integrity."
Report of Vice President - Communications and Marketing

Vice President John Lee reported that the 1978 NCSL Brochures and the Membership kits are in stock and available from the Secretariat.

Recommended Practices Committee

Bob Weber, committee chairman, reported that his committee has held two meetings since the October Board meeting. The committee plans to: (1) evaluate the need for additional recommended practices and refer any prospective ones to the appropriate Standing Committee; (2) determine the status of RP-1 and RP-2; (3) complete the edit of the second draft prepared by the Laboratory Evaluation Committee for the RP for use in the self-evaluation of calibration laboratories; and (4) assist the Information and Directory Committee in the organization and rewrite of Section IV, Recommended Practices of the Information Manual.

Information and Directory Committee

Jim Gilbert, chairman, reported that the Secretariat has distributed questionnaires for the 1979 NCSL Directory with the 1978 dues notices. This data will be used in the Directory, scheduled to be published in January 1979.

Regional Reports

Region 1

Moe Corrigan reporting for Harry Haynes, Regional Coordinator, indicates that a technical and business regional meeting will be held this March, with a follow-up meeting before the 1978 National Conference.

Region 2

Moe reported that Coordinator John Attansio has held several meetings. A meeting was held on November 3 at Leeds and Northrup, hosted by Dennis Gallagher. Thermocouple calibration was discussed, and a pilot training program was presented and discussed. On January 12, 1978, a meeting was held at RCA Somerville, Selwyn Smith hosting. John Hartman of RCA presented a talk on "Measurement of Micron Lines."

Region 3

Hugh Starling reported for Coordinator Marlin Johnson, whose January 18 meeting had to be canceled because of severe weather. This meeting was rescheduled for February 22. The third meeting is tentatively scheduled for May and will be held at the Hewlett Packard office in Rockville, Maryland. The principal topic will be Measurement Assurance Programs. Mr. Robert Shaw of Westinghouse was selected to serve as the Region's Measurement Assurance Committee representative.

Region 4

Moe McKinney reported for Regional Coordinator John Riley. The region continues to hold two meetings a year: one is scheduled for April 25 at Orlando, Florida; and the second one is scheduled for November 14, also in Orlando, Florida. The meetings are conducted on a round-table basis and developed from inputs from NCSL BOD, the Meetings and Programs Chairman, regional members, and other NCSL committee chairmen. The meetings qualify attendees for one recertification unit for ASQC certified quality engineers. Certificates reflecting this are issued to those attendees requesting them for this purpose.

Region 5

Cliff Koop, Regional Coordinator, reported that hotel conflicts required that its November 18, 1977, meeting be shifted to December 9 in Chicago. In spite of -5° temperatures and 30 mph winds, there were twelve attendees, including NCSL President, Laurel Auxter. Topics covered were Measurement Assurance Programs, NCSL/NBS Fellowship Program, MIL-C-45662A revision, and Quality of Precision Measurement Equipment as experienced by the Air Force.

The next meeting is scheduled for March 21, 1978, at Bond Court Hotel in Cleveland, Ohio. Joe Katoch of Gould, Inc., Instrument System Division, will be the host. Tentative plans call for more specific details on MAP by Norm Belecki of NBS.

Region 6

Sam Davidson reported for Paul Groos, Regional Coordinator, on its October 28, 1977, meeting hosted by Mr. Davidson, Schlumberger Well Services, in Houston, Texas. Topics of discussion were: Board of Directors Meeting Report, the Boulder Conference, NBS-MAP Program, and the Laboratory Accreditation Program.
Region 7
Bob Lady reported that Stephen Henneberry, the new Regional Coordinator, plans a regional meeting for May 24, 1978, in Seattle, Washington, to be coordinated with the next Board of Directors Meeting if possible.

Region 8
Bob Lady, reporting for Coordinator Rolf Schumacher, announced that its next meeting is scheduled for February 8, 1978, on the Queen Mary at Long Beach, California.

Subjects of the workshop meeting will be: (1) Work and Productivity Measurements, Performance Standards; (2) Calibration Intervals; (3) Report from BOD; and (4) Measurement Assurance Programs.

International Region
Regional Coordinator Mac McKinney reported that the region now has 20 paid members: 10 from industry; 8 from government agencies; and 2 from universities or institutes.

Liaison Reports
Measurement Science Conference
Dean Brungart reported that the conference held on December 2 and 3 at California State University at Long Beach was the most successful ever from a technical standpoint, an attendance record, and a financial point of view. Attendance was 480, 32% of the attendees having traveled over 500 miles and 21% of the attendees being from out of state. The next conference is scheduled for November 3 and 4, 1978, and will be held at California Polytechnic University at Pomona, California.

PMA
George Rice, Liaison Delegate, reported on the large and active part which PMA and its members had in the Measurement Science Conference: of 75 Program participants, 21 were members of PMA. Transfer of the PMA National Offices to the GIDEP Operations Center is progressing more slowly than planned due to work commitments of some of the officers. The formal transfer is still expected in early 1978.

GIDEP Metrology Committee
John Lee, Liaison Delegate, reported that the next GIDEP meeting will be held in March 1978.

MACTAB
No report.

ASQC
Liaison Delegate Max Uni reported that the next Annual ASQC Technical Conference will be in Chicago from May 8 through 15, 1978. The ASQC Metrology Technical Committee will meet during that conference, and Max will report on its activities.

OTML
Liaison Delegate Don Greb reported through Ron Kidd that no meeting has been held since the last Board meeting.

Proposed Bylaws Amendments
Jim Valentin submitted a written report containing some recommended changes affecting Articles II, III, IV, VI, VIII, and IX. An action schedule was developed so that the BOD will be able to consider the recommendations at the next board meeting.

NCSL/NBS Fellowship Program
John Minick, as chairman of the NCSL/NBS Fellowship committee, will be sending letters to appointing officers and others to solicit candidates for the program. [Editor's Note: See article on the Program elsewhere in this issue.]

Wildhack Award
John Minick assured the Board that there will be an award although the committee has not been active this year.

Next Board of Directors Meeting
Rescheduled for May 22 and 23 in Seattle, Washington.
### NCSL Budget for Fiscal Year 1977-78

(October 1, 1977, through September 30, 1978)

<table>
<thead>
<tr>
<th>Account</th>
<th>Budget</th>
<th>Expenses to Date</th>
<th>Budget Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA  - Meetings and Programs</td>
<td>$600.00</td>
<td>$0.00</td>
<td>$600.00</td>
</tr>
<tr>
<td>IB  - Honors and Awards</td>
<td>$3,000.00</td>
<td>$508.19</td>
<td>$2,491.81</td>
</tr>
<tr>
<td>IC  - Education and Training</td>
<td>$600.00</td>
<td>$314.16</td>
<td>$285.84</td>
</tr>
<tr>
<td>4A  - Newsletter</td>
<td>$8,000.00</td>
<td>$2,128.19</td>
<td>$5,871.85</td>
</tr>
<tr>
<td>4B  - Information and Directory</td>
<td>$5,500.00</td>
<td>$633.36</td>
<td>$4,866.64</td>
</tr>
<tr>
<td>4C  - Other Committees</td>
<td>$1,000.00</td>
<td>$0.00</td>
<td>$1,000.00</td>
</tr>
<tr>
<td><strong>Total Committee Accounts</strong></td>
<td><strong>$18,700.00</strong></td>
<td><strong>$3,583.86</strong></td>
<td><strong>$15,116.14</strong></td>
</tr>
<tr>
<td>B1  - Secretariat</td>
<td>$3,000.00</td>
<td>$1,200.00</td>
<td>$1,800.00</td>
</tr>
<tr>
<td>B2  - Stationery and Postage</td>
<td>$300.00</td>
<td>$244.36</td>
<td>$55.64</td>
</tr>
<tr>
<td>B3  - Petty Cash</td>
<td>$50.00</td>
<td>$0.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>C1  - President’s Expenses</td>
<td>$2,300.00</td>
<td>$835.00</td>
<td>$1,665.00</td>
</tr>
<tr>
<td>C2  - Treasurer’s Expenses</td>
<td>$400.00</td>
<td>$0.00</td>
<td>$400.00</td>
</tr>
<tr>
<td>C3  - Regional Meeting Support</td>
<td>$600.00</td>
<td>$73.64</td>
<td>$526.36</td>
</tr>
<tr>
<td><strong>Total Operating Expenses</strong></td>
<td><strong>$6,850.00</strong></td>
<td><strong>$2,353.00</strong></td>
<td><strong>$4,497.00</strong></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>$25,550.00</strong></td>
<td><strong>$5,936.86</strong></td>
<td><strong>$19,613.14</strong></td>
</tr>
</tbody>
</table>

L. R. "Bob" DeLapp, Treasurer

---

**Attendees at January Board of Directors Meeting**

- **President:** L. Auxier (Beckman Instruments, Inc.)
- **Executive Vice President:** R. E. Kidd (Microwave Associates)
- **Vice Presidents:**
  - D. Brungart (Teledyne Systems Company)
  - G. Cameron (Department of National Defence)
  - J. Lee (Honeywell, Inc.)
  - J. A. Valentino (Sanders Associates)
- **Secretary:** H. C. Keith (Aeronutronic Ford)
- **Treasurer:** R. DeLapp (SRI International)
- **Sponsor’s Delegate:** B. W. Birmingham (National Bureau of Standards)
- **Directors:**
  - M. J. Corrigan (Lockheed Electronics)
  - S. L. Davidson (Schlumberger Well Service)
  - R. M. Lady (Lockheed Georgia Co.)
  - J. C. McKinney (U.S. Army Metro. and Calib. Center)
  - H. C. Starling (General Electronic Corp.)
  - J. L. Minick (Hewlett-Packard)
- **Past President:**
- **Secretary:** L. K. Armstrong (National Bureau of Standards)
- **Regional Coordinator (5):**
  - C. D. Koop (Rockwell-Collins)
  - B. Belanger (National Bureau of Standards)
- **Co-chairman 1978 Conference:**
  - C. Davidson (TRW DSS6)
  - D. H. Callagher (Leeds and Northrup Company)
  - G. Rice (Rockwell-Automatics)
  - R. L. Weber (Lockheed Missile and Space Company)
WE're LOOKING FOR AN EXCEPTIONAL INDIVIDUAL!!

DO YOU KNOW A PERSON WHO CAN TAKE ON A STRATEGIC MANAGEMENT POSITION OF CONSIDERABLE IMPORTANCE TO BOTH NCSL AND NBS?

In the past several years the NCSL Board of Directors has defined and publicized the NBS/NCSL Fellow Program. This Program has been established and approved by the NCSL Board of Directors in conjunction with NBS, our sponsoring organization. The purpose of the program is to meet jointly the demands of the future in the general area of standards and calibration. The Office of the NBS/NCSL Fellow would become the focal point for a management-level interface between NBS and other government and industrial organizations in areas of measurement science, technology, safety, legal metrology, and other critical areas of mutual interest.

The Board of Directors has reconfirmed its strong commitment to establish the program. So far, the main delay has been our inability to find a candidate.

1. The NBS/NCSL Fellow would be an individual from an NCSL organization. The participant would reside at NBS at either its Gaithersburg, Maryland, or Boulder, Colorado, location. The logistics of the assignment would be mutually developed by the participant's organization, NCSL, and NBS. Salary will be shared by these organizations, and assignments are expected to be for a minimum of one year. (See the May 1976 NCSL Newsletter for details.)

2. The program parallels existing interchange programs and could be coupled with a program such as the NBS Research Associate Program or the President's Executive Interchange Program. While our NBS/NCSL Fellowship is in the development stages, these and other programs have been successfully accomplishing their purposes and objectives for many years.

3. The other programs have successfully addressed the problems of pay status, moving expenses, fringe benefits, bonuses, vacations, and seniority; and it is expected that similar details could be satisfactorily worked out among the candidate, the company, and NBS before commitments are finalized.

John Minck, this year's past president, has been appointed Chairman of the NBS/NCSL Fellowship Committee. He is working to identify potential candidates from NCSL ranks. All member delegates are asked to review possible names, not just from your metrology departments, but from all technical management channels in your organization.

We would appreciate it if you would review the program with your management. Even if you can't find a candidate, you might let us know what areas of the program may present problems for your organization. Candidates interested in the program should notify John Minck at the address below. Send your questions and comments to:

John Minck, NCSL Past President
Hewlett-Packard Company
1501 Page Mill Road
Palo Alto, CA 94304
(415) 493-1501, Ext. 2060
NEW MEMBERS OF NCSL

Centro Tecnico Aeroespacial
Instituto de Fomento e Coord. Ind.
Projeto Motorao Aeronautico
S. J. Campos - SP
Brazil, S.A. BR-12.200
Delegate: Walter Dos Santos

DHEW/AOSHS/TC8/QA
944 Chestnut Ridge Road
Morgantown, West Virginia 26505
Delegate: Ron Powelko

Frequency and Time Systems, Inc.
182 Conant Street
Danvers, Maine 01923
Delegate: Thomas J. Parello

General Motors Proving Ground
N-VEL Standards Laboratory
Milford, Michigan 48042
Delegate: James A. Verney

Hunt Metrology Service
175 Jackson Street
Waltham, Massachusetts 02154
Delegate: Lester W. Hunt, Jr.

ITR, Inc.
4053 Navajo Lane
Wichita, Kansas 67210
Delegate: Gerald D. Shrum

The Jamaican Bureau of Standards
6 Winchester Road
Kingston 10, Jamaica
Delegate: P. Folkes

Japan Electric Meters Inspection Corporation
5-6, 1-Chome Shibaura, Minato-Ku
Tokyo, 105, Japan
Delegate: Yasushisa Tsuruno

King Radio Corporation
400 E. Rogers Road
Olathe, Kansas 66061
Delegate: Don Qualman

NASA, Langley Research Center
Hampton, Virginia 23665
Delegate: Frederick A. Kern

Naval Avionics Facility
21st and Arlington Avenue
Indianapolis, Indiana 46218
Delegate: Thomas A. Pearson

Navy Calibration Laboratory
Naval Air Station, P. O. Box 117
FFD San Francisco, California 94637
Delegate: W. L. Gibbs

Northrop Corp. FPD
100 Morse Street
Norwood, Massachusetts 02062
Delegate: John Eramo

Northrup Page Communications Engineers, Inc.
801 Pollin Lane
Vienna, Virginia 22180
Delegate: Edward E. Brockway

Pacific Missile Test Center (4132)
Point Mugu, California 93042
Delegate: James A. Hubert

Systron Donner Inertial Division
1090 San Miguel Road
Concord, California 94518
Delegate: Richard Boyd

Warner Robbins Air Logistics Center
WR-ALC/MACL
Robins Air Force Base, Georgia 31098
Delegate: Raymond D. Grant

Wiltron Company
825 E. Middlefield Road
Mountain View, California 94043
Delegate: Peter Lacy

U.S. Instrument Rental
951G Industrial Road
San Carlos, California 94070
Delegate: Jack Cooper
MEMORANDUM TO: NCSI.

FROM: B. W. Birmingham, Sponsor's Delegate

SUBJECT: Sponsor's Delegate Report - Status of the NBS Reorganization

March 12, 1978

As you requested, I am pleased to tell you the current situation regarding the NBS reorganization. NBS began operating under the new structure March 12, 1978, and I would like to describe the present status and reiterate the advantages of this new organization.

The present organization has been in place for 13 years, and its structure is outlined in figure 1. In order to place it in perspective with the new structure, let me simply remind you that during this period NBS has operated with four major organizational units, known as Institutes. Although this arrangement has served us well, it has shortcomings, such as: isolation among various organizational units and disciplines; the time-consuming nature of program reviews; and the difficulty of explaining current programs to organizations providing financial support. There has also been some conflict between carrying out consumer-related programs and building scientific capabilities for the future.

The new organizational structure, which is designed to combat these problems, is shown in figure 2. This structure:

- Consolidates competences;
- Organizes along major functional lines; and
- Provides much greater flexibility than we currently have.

The number of formal organizational units is substantially reduced. Our intent is to push technical decisions as far down in the organization as possible and pull administrative support as high as we can. The paperwork burden will be reduced.

In general, this arrangement calls for grouping all technical staff competence into two laboratories: a National Measurement Laboratory (NML) and a National Engineering Laboratory (NEL).

NML

The National Measurement Laboratory will provide the measurement methods, standards, and data that are fundamental to science, industry, and commerce. This function requires a strong basic research capability in the physical sciences.
The National Engineering Laboratory will be working on the application of technology to the solution of a broad range of national problems, for example: fire research; building research; measurement of product performance; automation; and electronic technology. This function must be supported by programs in applied research.

Each of these laboratories is subdivided into "Centers." These "Centers" in the new NBS organization are each made up of a few divisions containing fewer people than in existing divisions--somewhere between 30 to 50 people each. Divisions in turn consist of technical teams headed by scientific team leaders.

Let me now return to the overall NBS organizational structure and briefly comment on some of the other organizational entities (figure 2).

ICST

This Institute continues in the new structure, and its major responsibility is in research, consultation, and the development of ADP standards as required under the Brooks Act. The ICST program is aimed at improving economy and efficiency in the Government's use of computers. It is a major growth area that has many concomitant benefits in all areas where computers are used.

A/D Programs, Budget, and Finance

In this area, the Office of the Comptroller has been consolidated with Program and Budget Analysis.

A/D Administrative and Information Programs

This is a consolidation of functions that were previously reported to two Associate Directors.

You may recall that in previous discussions with the Board, I referred to an Office of the Director of Technology Programs. This later evolved into the Programmatic Center for Cooperative Technology, whose present major function is to study the cooperative technology concept. Such a Center could, in part, be concerned with the development, improvement, and transfer of technology in instances where the private sector, acting alone, cannot or will not do the job. This Center is presently not included on our organizational chart.

The overall reorganization has support from the outside, including both our Statutory Visiting Committee and the National Academy of Sciences Panels. It also has the support of the Assistant Secretary for Science and Technology and his Deputy, who have helped us in its formulation and who support its implementation.

In general, we at NBS feel the prospects for the future look exciting and challenging as the overall plan is implemented. It shows great promise for strengthening the scientific and technical competences at NBS, as well as providing quicker responses to those who use our services. The opportunities for maintaining NBS as a first rank scientific organization are indeed great.
U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

DIRECTOR
Deputy Director

Office of Legal Adviser

OFFICE OF THE ASSOCIATE DIRECTOR FOR PROGRAMS

OFFICE OF EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM

OFFICE OF THE ASSOCIATE DIRECTOR FOR ADMINISTRATION

OFFICE OF THE ASSOCIATE DIRECTOR FOR INFORMATION PROGRAMS

OFFICE OF THE DEPUTY DIRECTOR INSTITUTE FOR BASIC STANDARDS/BOULDER

Electromagnetics Division
Time and Frequency Division
Quantum Physics Division
Cryogenics Division
Supply Services Division
Instrument Shops Division
Plant Division

INSTITUTE FOR BASIC STANDARDS

Applied Mathematics Division
Electricity Division
Mechanics Division
Heat Division
Optical Physics Division
Center for Radiation Research

INSTITUTE FOR MATERIALS RESEARCH

INSTITUTE FOR APPLIED TECHNOLOGY

INSTITUTE FOR COMPUTER SCIENCES & TECHNOLOGY

FIGURE 1
U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

DIRECTOR
Deputy Director

PUBLIC AFFAIRS
OFFICER

ASSOCIATE DIRECTOR FOR
PROGRAMS, BUDGET & FINANCE

LEGAL ADVISER

EEO PROGRAM
COORDINATOR

DIRECTOR OF ADMINISTRATIVE &
INFORMATION SYSTEMS

OFFICE OF THE DIRECTOR
NBS/BOULDER LABORATORIES

NATIONAL
MEASUREMENT LABORATORY

Center for Absolute Physical Quantities
Center for Radiation Research
Center for Thermodynamics & Molecular Science
Center for Analytical Chemistry
Center for Materials Science

NATIONAL
ENGINEERING LABORATORY

Center for Applied Mathematics
Center for Electronics & Electrical Engineering
Center for Mechanical Engineering & Process Technology
Center for Building Technology
Center for Fire Research
Center for Consumer Product Technology
Center for Field Methods

INSTITUTE FOR COMPUTER
SCIENCES & TECHNOLOGY

Systems & Software Division
Computer Systems
Engineering Division
Information Technology Division

FIGURE 2
OFFICE OF THE DIRECTOR--Director: Dr. John W. Lyons
Office of Engineering Standards--Chief: Mr. Gene A. Rowland; (301) 921-2128
Office of Energy Programs--Chief: Dr. Jack E. Snell; (301) 921-3275

Center for Applied Mathematics--Director: Dr. Burton H. Colvin; (301) 921-2341
Mathematical Analysis Division--Chief: Dr. Frederick C. Johnson; (301) 921-2631
Operations Research Division--Chief: Dr. A. J. Goldman; (301) 921-3835
Scientific Computing Division--Acting Chief: Dr. Burton H. Colvin; (301) 921-2341
Statistical Engineering Division--Chief: Dr. Harry H. Ha; (301) 921-2315

Center for Electronics and Electrical Engineering--Director: Mr. Judson C. French; (301) 921-3357
Electron Devices Division--Chief: Dr. W. H. Bullis; (301) 921-3786
Electrosystems Division--Chief: Dr. Oskars Petersens; (301) 921-3121
Electromagnetic Fields Division--Chief: Dr. H. S. Boyne; (303) 499-1000, x.4343 (Boulder, CO)
Electromagnetic Technology Division--Chief: Dr. R. A. Kemper; (303) 499-1000, x.3535 (Boulder, CO)

Center for Mechanical Engineering and Process Technology--Director: Dr. John Simpson; (301) 921-2171
Mechanical Processes Division--Chief: Dr. R. D. Young; (301) 921-2181
Fluid Engineering Division--Chief: Dr. G. E. Mattingly; (301) 921-3681
Thermal Processes Division--Chief: Dr. K. D. Kreider; (301) 921-3275
Industrial Engineering Division--Chief: Vacant
Acoustical Engineering Division--Chief: Dr. D. S. Fallett; (301) 921-3914
Thermophysical Properties Division--Chief: Dr. R. H. Kropschot; (303) 499-1000, x.4108 (Boulder, CO)

Center for Building Technology--Director: Dr. Richard N. Wright; (301) 921-3377
Structures and Materials Division--Chief: Dr. E. O. Pfrang; (301) 921-2196
Building Thermal and Service Systems Division--Chief: Dr. P. E. McNall; (301) 921-2196
Environmental Design Research Division--Acting Chief: Dr. Richard N. Wright; (301) 921-3704
Building Economics and Regulatory Technology Division--Chief: Mr. J. C. Gross; (301) 921-3447

Center for Fire Research--Acting Director: Dr. Fred B. Clarke; (301) 921-3143
Fire Science Division--Chief: Dr. R. S. Levine; (301) 921-3845
Fire Safety Engineering Division--Chief: Mr. L. A. Benjamin; (301) 921-3255

Center for Consumer Product Technology--Director: Dr. Stanley I. Warshaw; (301) 921-3751
Consumer Sciences Division--Chief: Dr. M. R. Meyerson; (301) 921-2900
Product Performance Engineering Division--Chief: Dr. Andrew J. Fowell; (301) 921-3748
Product Safety Technology Division--Chief: Mr. Walter Leight; (301) 921-3750

Center for Field Methods--Acting Director: Mr. Richard Penn; (301) 921-3185
OFFICE OF THE DIRECTOR—Director: Dr. John D. Hoffman

Office of Nondestructive Evaluation—Chief: W. Berger; (301) 921-3331
Office of Environmental Measurements—Chief: Vacant
Office of Standard Reference Materials—Chief: J. P. Cali; (301) 921-3479
Office of Standard Reference Data—Chief: Dr. D. R. Lide, Jr.; (301) 921-2407
Office of Measurements for Nuclear Safeguards—Chief: Dr. H. T. Yolken; (301) 921-3747
Office of Recycled Materials—Acting Chief: Dr. D. R. Johnson; (301) 921-3136
Office of Health Measurements—Chief: Vacant
Office of Energy Measurements—Chief: Vacant

Associate Director for Measurement Services, Dr. Arthur McCoubrey; (301) 921-3301
Office of Weights and Measures—Chief: Albert D. Tholen; (301) 921-3677
Office of Measurement Services—Chief: Dr. Brian C. Belanger; (301) 921-2805
Office of Domestic and International Measurement Standards—Chief: David Edgerton; (301) 921-3662

Center for Absolute Physical Quantities—Director: Dr. Karl G. Kessler; (301) 921-2001

Electrical Measurements and Standards Division—Chief: H. N. Taylor; (301) 921-2701
Temperature Measurements and Standards Division—Chief: Dr. J. F. Schooley; (301) 921-2801
Length and Mass Measurements and Standards Division—Acting Chief: Dr. K. G. Kessler; (301) 921-2001
Time and Frequency Division—Chief: Dr. J. A. Barnes; (301) 499-1000, x.3294 (Boulder, CO)
Quantum Physics Division—Chief: Dr. G. P. Dunn; (303) 499-1000, x.3518 (Boulder, CO)

Center for Radiation Research—Director: Dr. James E. Leiss; (301) 921-2251

Atomic Plasma Radiation Division—Chief: Dr. W. L. Wisec; (301) 921-2071
Nuclear Radiation Division—Chief: Dr. R. S. Caswell; (301) 921-2251
Radiation Physics Division—Chief: Dr. C. E. Kuyatt; (301) 921-2051
Radiometric Physics Division—Chief: Dr. J. L. Tech; (301) 921-3854
Radiation Source and Instrumentation Division—Chief: Dr. S. Penner; (301) 921-2293

Center for Thermodynamics and Molecular Science—Director: Dr. Milton D. Scheer; (301) 921-2713

Surface Science Division—Chief: Dr. C. Powell; (301) 921-2053
Chemical Kinetics Division—Chief: Dr. W. Tsang; (301) 921-2775
Chemical Thermodynamics Division—Chief: Dr. D. Garvin; (301) 921-2771
Thermophysics Division—Chief: Dr. H. J. Raveché; (301) 921-2811
Molecular Spectroscopy Division—Chief: Dr. M. M. Hessel; (301) 921-2021

Center for Analytical Chemistry—Director: Dr. Philip D. LaFleur; (301) 921-2251

Inorganic Analytical Research Division—Chief: Dr. I. L. Barnes; (301) 921-3674
Organic Analytical Research Division—Chief: Dr. R. S. Hertz; (301) 921-2134
Gas and Particulate Science Division—Chief: Dr. J. K. Taylor; (301) 921-2886

Center for Materials Science—Director: Dr. John B. Wachtman, Jr.; (301) 921-2891

Materials Stability, Durability, and Corrosion Division—Chief: Dr. T. B. Coyle; (301) 921-2847
Fracture and Deformation Division—Chief: Vacant
Polymer Science and Standards Division—Chief: Dr. R. K. Eby; (301) 921-3734
Metal Science and Standards Division—Acting Chief: Dr. A. W. Ruff, Jr.; (301) 921-2811
Ceramics, Glass, and Solid State Science Division—Chief: Dr. W. P. R. Frederikse; (301) 921-2845
Reactor Radiation Division—Chief: Dr. R. S. Carter; (301) 921-2421
U.S. NATIONAL LABORATORY ACCREDITATION PROGRAMS

This article is excerpted from a report prepared by Ted Young, Office of Product Standards, U.S. Department of Commerce, with assistance from the private sector for the International Conference on the Reciprocal Recognition of National Programs for Testing Laboratories at Copenhagen, Denmark, October 1977.

Background-History

Laboratory evaluation and accreditation in the United States has long been recognized as an important aspect of product assurance and certification systems. As requirements for product assurance have grown, generally on a product class or industry basis, laboratory accreditation and product certification systems have grown to meet the particular needs of the product or industry.

Some of these have been governmental systems but as many or more are nongovernmental and have developed voluntarily in our private enterprise system. Examples include Federal Government agencies with large procurement activity, such as the Department of Defense and the General Services Administration. They conduct qualification programs for laboratories that test electronics, personnel equipment, and various other products.

The U.S. Department of Agriculture conducts programs for qualification of laboratories that test meat and poultry. Many state governments, working through the American Association of Motor Vehicle Administrators or the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers have programs for automobile safety equipment and pressure systems. The Department of Health, Education and Welfare and the College of American Pathologists have, respectively, programs for licensing and accreditation of clinical laboratories.

Other programs are in development. The Food and Drug Administration has recently proposed rules for good practice for laboratories that perform premarket safety tests of food and drugs and is conducting inspections of such laboratories to assure the quality of their tests. The Environmental Protection Agency is concerned with the testing of toxicity and is also now developing a program to fulfill its responsibility of assessing drinking water test facilities.

Even considering these governmental programs, a large number of laboratory accreditation and product certification systems now functioning in the United States are nongovernmental private sector systems. The systems interface with the American Society for Testing and Materials and the American National Standards Institute (both nongovernmental bodies) for development of test methods and laboratory evaluation criteria.

The American Society for Testing and Materials, in conjunction with the American Association of State Highway and Transportation Officials, maintains a reference laboratory that evaluates hundreds of construction materials testing laboratories. The American National Standards Institute requires an evaluation of testing laboratories serving such programs for its accreditation of product certification programs. The Underwriters Laboratories (UL) requires a periodic check on the means the manufacturer exercises to determine compliance of the product with UL requirements for its authorization to use the widely recognized UL label. Underwriters Laboratories has developed procedures under which it will recognize test data produced by other laboratories...

The American Council of Independent Laboratories requires compliance with its criteria for testing laboratory quality control systems for accreditation.

The examples given are indicative of the broad interest in the United States regarding the qualification of testing laboratories. Other national and state agencies, industrial companies, trade associations and other groups concerned with testing laboratory performance promulgate criteria or implement laboratory evaluation programs. For product areas where quality assurance is important, one is likely to find some form of laboratory evaluation program, if there is for that product an entity having sufficient impact or authority to encourage laboratories to comply and if this entity can focus sufficient resources together to implement the program. Our delegation includes individuals who are knowledgeable about these governmental and nongovernmental activities.

The National Voluntary Laboratory Accreditation Program (NVLAP) was established on February 25, 1976. On that date, the U.S. Department of Commerce published procedures for NVLAP under Title 15, Part 7, of the U.S. Code of Federal Regulations. NVLAP provides a national focus in areas where adequate programs do not exist or where needs for national recognition and coordination are required.
The first requests for laboratory accreditation programs under NVLAP were received in December 1976. The first accreditation program (for testing of thermal insulation materials) was initiated October 12, 1977. Other requests are under review for accreditation programs in concrete testing and in calibration of radio and microwave frequency standards and instrumentation. Requests for programs in other product areas are known to be in preparation.

Goal and Purpose of NVLAP

The goal of NVLAP is to provide, in cooperation with the private sector, a national voluntary system to examine upon request the professional and technical competence of private and public testing laboratories that serve regulatory and nonregulatory product evaluation and product certification needs. The program will accredit those laboratories that meet necessary qualifications considered to be generally acceptable to laboratory users.

NVLAP provides for the establishment and implementation of programs for accreditation of processes for the testing of products, the calibration of standards and instruments, and the evaluation of design or specifications. NVLAP will accredit laboratory processes that serve the testing needs of product certification programs but will not accredit such certification programs since they generally include activities beyond NVLAP’s scope: e.g., production and marketplace surveillance, product or label recalls, etc. NVLAP prohibits its accredited laboratories from referencing their accredited status on product labels and requires laboratories to restrict their users from making such reference.

Scope or Limitations

NVLAP requires that a laboratory accreditation program specify the product for which laboratories would be accredited to serve. The product can be a type or category of processed or natural material, or manufactured goods, constructions or installations, or associated services such as design evaluation, calibration, or clinical analysis. The product testing requirements must be defined by existing product standards, test methods or recommended practices. NVLAP will not develop such standards or modify their requirements. NVLAP does not accredit laboratories for broad technical disciplines, such as metallurgical testing, chemical testing, or biological testing, or for areas such as safety testing or environmental testing unless such testing is associated with specific products.

There are no restrictions on the number or types of laboratories that may apply for and receive accreditation. Laboratories may be independent organizations, or be affiliated with, divisions of companies, associations, institutions, societies, or government. Domestic and foreign laboratories are equally eligible. Any testing laboratory will be accredited if it meets the established criteria, agrees to be examined on a continuing basis, pays necessary fees, and prohibits reference to its accredited status in consumer media, product labeling, and advertising.

Relationship to Other Affected Interests

NVLAP is intended to serve the needs of industry, consumers, government and others. Whereas NVLAP is a government program administered according to established Federal regulations, such regulations apply only to the relationship of NVLAP to other affected interests. The relation-
ship of other affected interests to NVLAP will depend upon their voluntary actions. Although it is expected that affected interests in government and the private sector will seek the services of NVLAP, the extent and nature of such relationships are still to evolve.

NVLAP procedures contain requirements specific to the relationship of NVLAP with others. The program is required to undertake and maintain consultation and coordination with Federal, state, and local government agencies, with professional and trade associations and societies, and with others of the private sector to maximize benefits derived from other laboratory examination and accreditation activities. In particular, NVLAP will not initiate a laboratory accreditation program for a product area that would affect an existing or developing program of a Federal regulatory agency without that agency’s approval.

Other NVLAP procedures indicate the nature of the program’s relationships to standards writing bodies. Laboratory accreditation programs initiated under NVLAP must be based upon existing product and test method standards, and accreditation criteria promulgated by NVLAP will, where appropriate, be based upon criteria found in existing standards. NVLAP cannot develop or modify the requirements of product and test method standards used in its laboratory accreditation programs, nor can NVLAP require that such standards be developed or approved by particular standards bodies. Standards are considered appropriate if they are important to commerce, consumer well being, or the public health or safety and if the methods of test are capable of ascertaining product conformity to the standard.

As indicated previously, NVLAP prohibits accredited laboratories from referring to their accredited status in product labels or advertising. Therefore, the relationship between the program and product certification agencies will be that of providing such agencies with increased assurance regarding the technical competence of testing laboratories they may wish to use. The prohibition regarding product labeling and advertising will help prevent the public from confusing laboratory accreditation with product certification.

Impact

As NVLAP has just initiated its first laboratory accreditation program, a statement concerning the impact of NVLAP would be premature. It can be stated, however, that considerable interest was demonstrated by government, the testing laboratory community, and the users of testing laboratories during the development and establishment of NVLAP. In the majority, such interests supported the need for a national laboratory accreditation program. NVLAP has attempted, within the limitations of its legal authority, to incorporate characteristics of a national program considered to be desirable by a consensus of affected parties. Whether NVLAP, as presently structured, can adequately and credibly serve national needs for testing laboratory assurance remains to be determined.

NCSL MEMBERSHIP KITS AVAILABLE FROM THE SECRETARIAT

Information about NCsl, its goals and activities, is available in the form of a Membership Kit. The kit contains a brochure describing the organization and goals of NCsl, a 1977 Directory of Standards Laboratories, and a sample copy of the NCsl Newsletter.

To obtain a kit, write to Ken Armstrong, NCsl Secretariat, c/o National Bureau of Standards, Boulder, Colorado 80303.
Dr. Ernest Ambler became Director of the National Bureau of Standards (NBS), an agency of the U.S. Department of Commerce, on Friday, February 3, 1978.

Ambler is the eighth Director in the 76-year history of the Nation's physical science and measurement laboratory. He has been serving as Acting Director of NBS since July 1975.

The appointment as director followed confirmation of Ambler's nomination by the U.S. Senate and acceptance of President Carter's Commission of Office.

Ambler joined NBS in 1953 as a research physicist. His administrative responsibilities began in 1961 when he was named chief of the Cryogenics Physics Section. Four years later, he was appointed chief of the Inorganic Materials Division.

In 1968, he was named director of the Institute for Basic Standards. As IBS Director, Ambler directed the most basic of NBS research activities: developing and maintaining standards and measurement techniques for such quantities as length, mass, time and frequency, and temperature.

In 1973 Ambler was appointed Deputy Director of NBS and became responsible for assessing the technological competence of Bureau programs and for unifying the approach to budgeting and programming.

Ambler has had a continuing interest in NBS' international activities that can support U.S. foreign commerce through participation in international standardization activities. In 1972 he was elected to serve as the U.S. representative to the International Committee of Weights and Measures. He also serves as chairman of the international organization's Consultative Committee on Standards for Measuring Ionizing Radiations.
The NCSL Long Range Plan Draft dated December 1, 1977, Section 2B, page 20 directs the Chairman of the Laboratory Evaluation Committee to sponsor, promote, or at least investigate the feasibility of NCSL's requesting a Laboratory Accreditation Program for Metrology Laboratories.

My discussions with officials from the Department of Commerce and NBS personnel associated with NVLAP clearly result in the conclusion that such a request is not within the scope of NVLAP. Supporting this conclusion is the following quote from Dr. Forman:

"NVLAP requires that a laboratory accreditation program specify the product for which laboratories would be accredited to serve. The product can be a type or category of processed or natural material, or manufactured goods, constructions or installations, or associated services such as design evaluation, calibration, or clinical analysis. The product testing requirements must be defined by existing product standards, test methods, or recommended practices. NVLAP will not develop such standards or modify their requirements. NVLAP does not accredit laboratories for broad technical disciplines, such as metallurgical testing, chemical testing or biological testing, or for areas such as safety testing or environmental testing unless such testing is associated with specific products."

Thus, the accreditation of a metrology lab would have to be limited to a specific product as defined by NVLAP, and conceivably there would be dozens of programs involved in the total accreditation of any moderately sized metrology laboratory.

LOW FREQUENCY ELECTRICAL MEASUREMENTS SEMINAR
April 24 through 27, 1978

This 4-day seminar, to be held at the National Bureau of Standards in Gaithersburg, Maryland, will present information on the accurate measurement of electrical quantities and the calibration of electrical standards. It will cover the measurement methods used by NBS to establish and maintain the basic electrical units and to calibrate customers' standards of resistance, voltage, current, reactance, and power from direct current up through 100 kHz.

TOPICS:

Electrical Units
Cryogenic Metrology
High Direct Voltage Measurements
Standards and Specifications for Data Conversion Equipment
Application of Digital Instrumentation

DC Bridge Methods
AC Bridge Methods
Power and Energy Measurements
Phase Angle Measurements
Status Report on Interface Standards
Measurement Assurance Programs

DC Voltage Measurements
AC-DC Transfer Measurements
Data Acquisition Devices for Supporting Electrical Measurements
Measurement Statistics
Automatic Measurement Systems

REGISTRATION: Attendance will be limited to 50 persons. Laboratory demonstrations will be divided into subgroups. Fee: $240. (Checks payable to: Low Frequency Seminar).

A total of $94,364,000 is included for the Commerce Department's National Bureau of Standards (NBS) in the Budget of the United States for Fiscal Year 1979.

The budget request is $22,818,000 above the FY 1978 operating level of $71,566,000. The 32 percent increase in funding is aimed at strengthening research on physical measurements, basic science, and materials, and at developing computer standards.

Dr. Ernest Ambler, NBS Director, said, "If appropriated by Congress, this will be the largest dollar increase in the history of the Bureau. The additional funding would allow NBS, as the Nation's central measurement and reference laboratory, to rebuild state-of-the-art capabilities in various technical competence areas and to acquire the necessary experience to carry out additional fundamental research in basic areas."

The total budget for NBS could total $155 million in FY 1979, up from $136 million for the current fiscal year. The total figure includes the direct congressional appropriation request, reimbursable work which NBS performs for other Federal agencies and the public, and sales of Bureau goods and services such as Standard Reference Materials and calibrations.

A breakdown of the budget request for FY 1979 follows. The largest single increase in the request is in the area of computer technology. The budget request is $21 million in FY 1979, an increase of more than $14 million and nearly two and one-half times the current funding level. Most of this money would be used to meet responsibilities for developing Federal automatic data processing standards assigned to NBS under Public Law 89-306, also referred to as the Brooks Act. The Bureau's program in automation technology would also be expanded by an additional $753,000 to provide measurement technology, standards, and calibration services for automated manufacturing systems. These are needed by U.S. industry to increase productivity and remain competitive internationally.

More than $23 million is being requested in the area of physical measurements, units, and standards, an increase of $2 million over FY 1978. The money would be used to rebuild technical competence by assembling needed scientific talents and to increase basic research. In addition, more than $2 million will be transferred to the working capital fund to continue modernization and replacement of existing equipment.

A $3 million increase is being requested for work in the materials area. The nondestructive evaluation program would be expanded substantially in the FY 1979 budget, with additional funds of $925,000. And if the budget request of $620,000 is authorized, the power output of the NBS research reactor will be doubled, from 10 to 20 megawatts. This would greatly increase the range of applications and services available at the reactor, a unique facility in the Washington, D.C., area.

The $3 million increase also includes a supplemental request of $1.6 million for FY 1978 for the Recycled Oil Program to continue development of test procedures and standards for recycled oil. These are responsibilities delegated to NBS by the Energy Policy and Conservation Act (Public Law 94-163).

A new area in the budget for FY 1979, titled "cooperative technology," is $2 million to develop and refine an NBS approach to supporting U.S. industrial technology through a collaborative program with industry, universities, and other Federal agencies. The objective of this effort would be to foster the development and utilization of technologies that are critical to the competitive health of selected U.S. industries.

An additional $850,000, listed in the table as "central planning," is being requested to assess and identify opportunities for NBS to invest its resources to provide greater benefits to the Nation. Proposed mechanisms for increasing the transfer of information and technology that result from NBS programs to the public would also be evaluated.

Virtually all other areas of the NBS budget would remain constant for FY 1979, allowing for inflation. An exception is the air and water pollution measurement program, where direct funds from Congress would be reduced by $1.9 million to a level of $348,000. This reduction reflects Administration policy that air and water pollution measurements and standards are the responsibility of the Environmental Protection Agency as the lead agency for achieving national environmental objectives. It is expected that work in this area will continue in FY 1979, but will be supported largely by EPA funding rather than by direct congressional funding to NBS.
ESTIMATED NBS OPERATING FUNDS
(Congress Only)
(in millions of dollars)

<table>
<thead>
<tr>
<th>Area of Service</th>
<th>FY 77 (actual)</th>
<th>FY 78 (estimate)</th>
<th>FY 79 (request)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical measure</td>
<td>28.8</td>
<td>28.4</td>
<td>32.4</td>
</tr>
<tr>
<td>Physical measures, units and standards</td>
<td>20.3</td>
<td>19.4</td>
<td>23.1</td>
</tr>
<tr>
<td>Reference measurements for physical quantities</td>
<td>8.5</td>
<td>9.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Provide services to improve use of materials</td>
<td>19.7</td>
<td>19.6</td>
<td>22.2</td>
</tr>
<tr>
<td>Properties and performance of materials</td>
<td>15.8</td>
<td>15.6</td>
<td>19.9</td>
</tr>
<tr>
<td>Reference materials</td>
<td>.9</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Environmental pollution measurements (Air, water, and noise)</td>
<td>3.0</td>
<td>3.0</td>
<td>1.2</td>
</tr>
<tr>
<td>Provide services to improve the application of technology</td>
<td>10.1</td>
<td>9.3</td>
<td>12.7</td>
</tr>
<tr>
<td>State weights and measures services</td>
<td>.6</td>
<td>.7</td>
<td>.7</td>
</tr>
<tr>
<td>Voluntary engineering standards</td>
<td>1.7</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Building science and technology</td>
<td>4.3</td>
<td>4.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Electronic technology</td>
<td>1.0</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Product Technology</td>
<td>2.5</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Cooperative technology</td>
<td>——</td>
<td>——</td>
<td>2.0</td>
</tr>
<tr>
<td>Central planning</td>
<td>——</td>
<td>——</td>
<td>.9</td>
</tr>
<tr>
<td>Improve the application of computer technology</td>
<td>6.5</td>
<td>6.4</td>
<td>21.0</td>
</tr>
<tr>
<td>Experimental Technology Incentives Program</td>
<td>3.1</td>
<td>3.1</td>
<td>3.2</td>
</tr>
<tr>
<td>Capital transfer and facilities</td>
<td>.7</td>
<td>2.1</td>
<td>.4</td>
</tr>
<tr>
<td>Transfer to working capital</td>
<td>2.1</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>71.0</td>
<td>71.5</td>
<td>94.3</td>
</tr>
</tbody>
</table>

All figures are rounded.
QUALITY OF PRECISION MEASUREMENT EQUIPMENT

By Clyde Moss
Aerospace Guidance and Metrology Center

As Presented at the Seventh Annual Measurement Science Conference

In thinking back through the years, I can recall missile system contractors stressing accuracies and reliability of their support equipment in order to insure that system performance would meet their contract criteria. One such example was the insistence on the part of a missile contractor that Simpson 260 multimeters had to be calibrated every ninety days or else his installation efforts would be questionable and he would not stand behind them. During these same time periods, instrument representatives and manufacturers were complaining about "copy contracts" and "low bidder awards" to "loaf manufacturers." The situation has changed through the years, particularly within the Metrology and Calibration (METCAL) Program. Procurement of standards centers around the "giants" of the industry, and, with the exception of a small percentage that require research and development, the majority are purchased from catalog descriptions of commercial off-the-shelf items. The Directorate of Metrology at the Aerospace Guidance and Metrology Center (AGMC) is responsible for planning, budgeting, and procurement of reference and working standards in support of the Air Force METCAL program of which there are 126 precision measurement equipment laboratories (PMEL's) located throughout the world. These measurement standards are in turn used as basic reference for all Air Force systems, subsystems, and equipment. It is our goal to procure the best equipment available, which means we are dealing with the most reliable manufacturers in the country. It is not a case of individual negotiations forcing the manufacturer to sacrifice his expected margin of profit since most of this equipment is procured through the use of GSA schedules with the balance being obtained through advertised purchase descriptions. During the fiscal year '77 time frame, we purchased approximately $3 million dollars worth of standard commercial off-the-shelf equipment.

For the most part, acceptance inspection was accomplished at AGMC. Historically, the reject rate for equipment procured by AGMC has been 20-25 percent. During the past two years AGMC has procured over 1500 measurement equipment items from about 75 different manufacturers. Records maintained by AGMC on acceptance testing and initial calibration of new equipment reflect a deterioration in the quality of equipment being received from industry. In looking at a select group of 490 items, we note that 211 of these did not meet manufacturers' published catalog specifications. This represents a reject rate of 43.1 percent. This category consists of commercial off-the-shelf type equipment, representative of the type that all industry procures. Needless to say, the quality of equipment being received from industry was less than desirable and appears to be getting worse. The nature of the rejects suggests that the equipment deficiencies exist prior to delivery or the component changes occur during and after delivery, and an insignificant number can be attributed to mishandling or inadequate packaging practices.

The manufacturers have corrected the equipment deficiencies without cost to the government, thus signifying they were in agreement with the AGMC findings—that the specifications were realistic and obtainable. It is interesting to note that we have been involved in only one lawsuit during the past 15 years concerning research of equipment, and the case was settled in favor of AGMC. Warranties and guarantees have been helpful to our cause; however, in some cases loss of the use of the equipment has hampered program support and in some cases compromised weapons systems deployment. Needless to say, the cost of reworking, retesting, and return shipping must be respected in future charges to the customer, so the "free guarantee" is not a reality. In looking at the overall quantity of equipment procured over the past two years, we focused our attention on the multifunction and more complex items since this group appeared to exceed the normal reject rate of 20 percent that we had learned to accept. The following outlines will demonstrate the experiences we have recorded, starting in 1969.

BACKGROUND

- AGMC/Metrology Budgets/Buys
- Air Force Reference Standards
- Air Force Base Reference Standards
- PMEL Working Standards/Accessories
- EQUIPMENT IS PROCURED VIA
  - GSA Schedule
  - Purchase Descriptions/Military Specifications
CONCLUSIONS

Prior to 1977, the following conclusions were reached:

Quality of new equipment from industry was unsatisfactory.
Major deficiencies related to complex/multifunction equipment.
Most quality deficiencies could be attributed to failure to meet catalog specifications.
Quality of equipment delivered to other activities may be worse than at AGMC, considering:

- 100% Inspection at AGMC
- Full Parameter Check
- Firm Rejection Criteria

As of October 1977:

- Quality of new equipment from industry shows improvement but is still unsatisfactory.
- One out of every six complex/multifunction equipment items delivered to Air Force field activities do not meet specifications (one out of ten require action beyond adjustment).
- Even though transportation and repair costs are absorbed by the manufacturer, the Air Force is deprived of the use of required equipment for long periods of time.

Based on our experience, it would appear prudent for all organizations involved in equipment acquisition to take a closer look at quality of new equipment.
A single measurement can be the basis for actions taken to maintain our health, safety or the quality of our environment. It is important therefore that the errors of measurement be small enough so that the actions taken are only negligibly affected by these errors. We realize this necessity on a personal basis when we consider medical measurements, or our exposure to radioactivity. In any government regulatory action or measurement involved in legal actions it is also obvious that the shadow of doubt surrounding the measurements should be suitably small. But this is no less true for all other measurements in science and industry and even though legal action may not be involved, the validity of scientific inference, the effectiveness of process control, or the quality of production may depend on adequate measurements [2].

Allowable Limits of Measurement Error

How does one achieve this condition— that the measurements are "good enough" for their intended use? It would seem obvious that one has to start with the need— i.e., deciding upon what is "good enough". There are a number of cases where physiological restraints provide the definition such as in the allowable error in exposure to cobalt radiation in cancer treatment or in the amount of pollutant entering a lake. In nuclear materials control the allowable error is a function of the amount of material which would pose a hazard if diverted. In industrial production or commercial transactions, the error limit is determined by a balance between the cost of better measurement and the possible economic loss from poorer measurement.

By whatever path such requirements are arrived at, let us begin with the assumption that the allowable error should not be outside the interval (-a, +b) relative to the quantity being measured. Our problem is one of deciding whether the uncertainty of a single measurement is wholly contained in an interval of that size. We therefore need a means of assigning an uncertainty to a single isolated measurement, and, in fact, we need a perspective (i.e., physical and mathematical model) in which to view measurement so as to give operational meaning to the term "uncertainty."

Reference Base to Which Measurements Must Be Related

It is instructive to contemplate the possible "cross-examination" of a measurement if it were to become an important element in a legal controversy. Two essential features emerge. First, that the contending parties would have to agree on what (actually realizable) measurement would be mutually acceptable. The logic of this seems unassailable—if one cannot state what measurement system would be
accepted as "correct," then one would have no defensible way of developing specifications or regulations involving such measurements. Second, the scientific cross-examination by which one establishes the "shadow of doubt" relative to this acceptable value gives one the uncertainty to be attached to the measurement.

The consensus or generally accepted value can be given a particularly simple meaning in dealing with measurements of such quantities as mass, volt, resistance, temperature, etc. One may require that uncertainties be expressed relative to the standards as maintained by a local laboratory, or, when appropriate, to the national standards as maintained by NBS. In other cases, nationally accepted artifacts, standard reference materials or in some cases a particular measurement process may constitute a reference base. One basic quality should not be overlooked—all are operationally realizable. The confusion engendered by introducing the term "true value" as the correct but unknowable value is thus avoided.

Properties of Measurement Processes

In discussing uncertainty, we must account for two characteristics of measurement processes. First, repeated measurements of the same quantity by the same measurement process will disagree and, second, the limiting means of measurements by two different processes will disagree. These observations lead to a perspective from which to view measurement namely that the measurement be regarded as the "output" of a process analogous to an industrial production process. In defining the process, one must state the conditions under which a "repetition" of the measurement would be made, analogous to defining the conditions of manufacture in an industrial process.

The need for this specification of the process becomes clear if one envisions the "cross-examination" process. One would begin with such questions as

- Within what limits would an additional measurement by the same instrument agree when measuring some stable quantity?
- Would the agreement be poorer if the time interval between repetitions were increased?
- What if different instruments from the same manufacturer were used?
- If two or more types (or manufacturers) were used, how much disagreement would be expected?

To these can be added questions related to the conduct of the measurement.
What effect does geometry (orientation, etc.) have on the measurement?

What about environmental conditions—temperature, moisture, etc.?

Is the result dependent on the procedure used?

Do different operators show persistent differences in values?

Are there instrumental biases or differences due to reference standards or calibrations?

The questions serve to define the measurement process—the process whose "output" we seek to characterize.

The current understanding of a scientific or industrial process or of a measurement process is embodied in a physical model which explains the interactions of various factors, corrections for environmental or other effects, and the probability models necessary to account for the fact that repetitions of the same event give rise to nonidentical answers. For example, in noise level measurement one is involved with assumptions regarding frequency response, weighing networks, influence of procedures and geometry, and an accepted theory for making corrections for temperature and other environmental factors. In mass the properties of the comparator (balance) the environmental effects, and the procedure used all enter into the description of the method.

One thus begins with the specification of a measurement method—the detailed description of apparatus, procedures and conditions by which one will measure some quantity. Once the apparatus is assembled and checked out, one has a measurement process whose output can be studied to see if it conforms to the requirement for which it was created.

In industrial production one tries to produce identical items but usually a measurement process is set up to measure a variety of quantities and ordinarily one does not measure the same quantity over and over. One thus has the problem of sampling the output of the measuring process so as to be able to make statements about the health of the process relative to the needs. The needed redundancy can sometimes be achieved by remeasuring some of the items, or by measuring a reference artifact periodically. It is essential that the repetitions be done under the same diversity of conditions as the regular measurements, and that the items being measured be typical of the regular workload.

As an example, a sequence of measurements was made using two sound level meters to measure a sound of nominally 90 dB re 20 μPa. The sound was generated by a loudspeaker fed broadband noise. On 16
different days measurements were made outdoors and over grass with the loudspeaker in the same orientation and location relative to a building 2 m behind the loudspeaker. The sound level meter was always the same distance (10 m) from the loudspeaker and on a line perpendicular to the face of the loudspeaker. Other than the grass, the person holding the sound level meter, and the building to the rear of the loudspeaker, there were no other reflecting surfaces or obstacles within 50 m. No measurements were made in the rain or in winds exceeding a few km/hr. The results from these 16 repetitions are shown in Figure 1. Typically, had duplicate measurements been made on the same day they would have given results as shown in Figure 2.

**Figure 1:** Day-to-Day Variation in Meter Readings.

**Figure 2:** Day-to-Day Variation in Meter Readings with Multiple Values Per Day. (Coincident Points Indicated by Numbers.)
One now faces the question of how to describe the variation that exists. Obviously there will be a different level of agreement expected between pairs on the same day, but this variation in no way predicts that encountered from day-to-day. The issue is not so much the statistical procedures to be used—these will follow after one defines the set of repetitions over which his conclusions must apply. For measuring the short term change in noise level, the difference between duplicates would apply; for any regulatory action, the day-to-day variation would have to be considered.

The crucial step in assessing the effects of random error is that of defining the set of repetitions over which the measurement is to apply. In the context of legal proceedings, one arrives at the degree of credibility of evidence by questions designed to find out how far the statement could be in error. In measurement, the uncertainty is arrived at by determining the amount of disagreement expected in the set of repetitions that would be appropriate in the context of the intended use of the measurement.

The Concept of a Repetition of a Measurement

Every measurement has a set of conditions in which it is presumed to be valid. At a very minimum, it is the set of repeated measurements with the same instrument-operator procedure-configuration. (This is the type of repetition one would envision in some process control operations.) If the measurement is to be interchangeable with one made at another location, the repetition would involve different instrument-operator-procedure-environment configurations. (This type of repetition is involved in producing items to satisfy a specification and of manufacturing generally.) When the measurement is to be used for conformance to a health, safety, or environmental regulation even different methods may be involved in a "repetition."

To evaluate a measurement process some redundancy needs to be built into the system to determine the process parameters. This redundancy should be representative of the set of repetitions with which the uncertainty statement is to apply. In NBS' measurements of mass, a check standard is measured in parallel with the unknowns submitted for calibration. One thus generates a sequence of measurements of the same object covering an extended time period. From these results one can answer questions relating to the agreement expected in a recalibration and the operating characteristics of the measurement process. In this simple case the check standard is treated exactly the same way as the unknowns so that the properties of the process related to it are transferrable to the unknown.

The essential characteristic in establishing the validity of measurement is predictability that the variability remains at the same level and that the process has not drifted or shifted abruptly from its established values. One must build in redundancy in the form of a
control—the measurement of a reference quantity of known value—or by remeasuring some values by a reference method (or by an instrument with considerably smaller uncertainty). In cases where the phenomenon can be repeated, one can learn about random errors by remeasuring at a later time sufficiently far removed to guarantee independence.

In measuring an "unknown" one gets a single value, but one still is faced with the need to make a statement that allows for the scatter of the results. If we had a sufficiently long record of measurements, we could set limits within which we were fairly certain that the next measurement would lie. Such a statement should be based on a collection of independent determinations, each one similar in character to the new observation, that is to say, so that each observation of the collection and also the new observation can be considered as random drawings from the same probability distribution. These conditions will be satisfied if the collection of points is from a sufficiently broad set of environmental and operating conditions to allow all the random effects to which the process is subject to have a chance to exert their influence on the variability. Suitable collections of data can be obtained by incorporating an appropriate reference measurement into routine measurement procedures, provided they are representative of the same variability to which the "unknown" is subject. The statistical procedures for expressing the results will depend on the structure of the data but they cannot overcome deficiencies in the representativeness of the values being used.

The results from the reference item provide the basis for determining the parameters of the measurement process and the properties are transferable. One is saying, in effect, if we could have measured the "unknown" again and again, a sequence of values such as those for the reference item would have been obtained. Whether our single value is above or below the mean we cannot say, but we are fairly certain it would not differ by more than the bounds to the scatter of the values on the reference item.

The bound +3, to be used for the possible effect of random errors may be as simple as +3 (standard deviation) or may involve the combination of many components of variance. Once the set of repetitions over which one's conclusions must apply is defined, the structure of the random error bound can be determined.

Possible Offset of the Process

Once one has established that his measurement process is "in control" from the point of view of random variation, there remains the question of the possible offset of the process relative to other processes. It is not helpful to speak of the offset from a "true value" which exists only in the mathematical or physical model of the process. The usefulness of considering measurement in the context of legal proceedings helps clear away some of the classical confusion about
errors of measurement. In a legal or regulatory setting, one is forced to state what would be accepted as correct such as comparison (by a prescribed process) with national standards or with the results from a designated laboratory or consensus of many laboratories.

The idea of defining uncertainty as the extent to which a measurement is in doubt relative to a standard or process defined as correct finds expression in the recent Nuclear Regulatory Commission statement [12]:

70.57(a) "Traceability" means the ability to relate individual measurement results to national standards or nationally accepted measurement systems ... (italics added)

One could measure the offset of his process relative to the accepted process, and make suitable corrections to eliminate the offset. However, for most processes, one is content with setting bounds to the possible offset due to factors such as:

Errors in the starting standards

Departures from sought-after instrumentation (e.g., geometrical discrepancies)

Errors in procedures, environment, etc.

and other effects which are persistent. From properly designed experiments one can arrive at a limit to the possible extent of errors from these sources in answer to the question, "If the process were set up ab initio, how large a difference in their limiting means would be reasonable?"

A bound to a number of factors can be determined as part of regular measurement. For example, the effect of elevation on sound level measurements could be evaluated by occasionally duplicating a measurement at a different height and taking an appropriate fraction of the observed difference as the limit to the possible offset due to any error in setting elevation. Figure 3 shows some results from sound level meters at two heights with the source at a constant height.

![FIGURE 3: DIFFERENCE BETWEEN METER VALUES WITH CHANGE IN HEIGHT](image-url)
Even if one has a functional relation, $y = f(h)$, expressing the dependence of the result, $y$, on height, $h$, one still has to carry out these measurements. The usual propagation of error approach involving partial derivatives, etc., implies that all instruments are equally dependent on the parameter under study, that there are no effects related to the factor except that contained in the formula. This can be verified for a particular instrument by actually measuring its response.

A similar comparison was made for a different orientation of the instrument with respect to this signal source and is shown in Figure 4. The effect of orientation is negligible and one would not be justified in adding an allowance for possible systematic error from this source based on a theoretical calculation.

![FIGURE 4: DIFFERENCE BETWEEN METER VALUES WITH A CHANGE IN ORIENTATION](image)

From these measurements, one will have a set of bounds $E_1$, $E_2$, $E_3$, ... to the possible offset or systematic error from the various factors. The question as to how to combine these to a single bound to the possible offset depends on knowledge of the joint effects of two or more factors and on the physical model assumed for the process. For example, if the bounds $E_i$ and $E_j$ arise from independent random error
bounds, then it would be appropriate to combine them in quadrature, i.e., $\sqrt{E_1^2 + E_2^2}$. An error in the model e.g., assumed linearity even when nonlinearity exists) would act as an additive error. The properties of any combination rule can be evaluated and a selection made of the most appropriate. The result will be an overall value, $E$, for the possible offset for the limiting mean of the process from that of the nationally accepted process.

**Uncertainty**

What can one say about the uncertainty of a measurement made by a process that may be offset from the nationally accepted process by some amount $+E$, and is subject to random errors bounded by $+R$? How should these values be combined? To begin with, one could raise the question, "If the random error could be made negligible, what uncertainty would one attach to a value from the process?" Clearly the answer is $+E$. The next question, "If, in addition, a random error of size $R$ is possible, what do we now say about the uncertainty?" The answer seems obvious—$E$ and $R$ are added to give an uncertainty of $[E + R]$. But what if $E$ were itself the result of only random errors? The answer depends on what one calls a repetition. By the way $E$ is defined, it is the bound for the systematic offset of the process and although it may be arrived at from consideration of random errors, the factor involved keeps the same (unknown) value throughout. Our ignorance does not make it a random variable.

Consider the case of a mass standard. NBS' certificate states that the uncertainty is based entirely on random variation, the effects from systematic errors being negligible. But unless one recalibrates, the error due to calibration remains fixed in all measurements by the user.

The uncertainty of a measurement—the width of its "shadow of doubt" in a legal proceeding—must therefore be the sum of the random error and systematic error limits.

**Measurement Process Control**

The essential feature for the validity of the uncertainty statement is that the process remain in a state of statistical control. Once an out-of-control condition occurs, one has lost predictability and the previous uncertainty statements are no longer valid.

To monitor the process some redundancy has to be built into the system. A variety of techniques can be used to give assurance of continued control. For example, one could periodically measure the same reference item or artifact or one could make duplicate measurements on some production items with enough delay to guarantee
independence. The American National Standards Institute Standard N15.18 for mass measurement \[10\] is an example where this approach is worked out in detail. But one has to verify more than just those parameters related to random variations. One needs to build in tests of the adequacy of the physical model by a variety of tests on the process (e.g., by repeating measurements under different conditions to verify the adequacy of the corrections for such changes) as well as periodic redetermination of the bounds for systematic error. One thus tests that the assumed model is still acceptable and that the parameters assigned to that model have not changed.

An excellent example of the efficacy of this approach is given by the recent announcement \[6\] of discrepancies of 1 mg in the assignment of mass to aluminum kilogram standards. The mass measurement system has long been shown to be nearly perfect for the usual standards. To check up on the performance of the system at densities nearer to that of most objects involved in practical measurement, an aluminum kilogram was sent to laboratories including several at high elevations. It turns out that the difference between the mass of a stainless steel and an aluminum kilogram is significantly different at different elevations. This unsuspected property of the real measurement system is now the subject of considerable study.

All measurements have some form of measurement assurance program associated with them although, as with quality control, we usually reserve the term for a formal program. In a formal program one treats the whole process--beginning with a study of the need, the development of a measuring process and a procedure for determining and monitoring its performance, and an evaluation of the effectiveness of the whole effort. One needs a criterion of success to be able to determine whether more of one's current measurement activity or perhaps some alternative would contribute most to the overall program, and this is not necessarily provided by the smallness of the uncertainty for a measurement.

For example, when the requirement is for matched sets (e.g., ball bearings) or mated assembly parts, then it is usually cheaper and more accurate to sort into finely divided classes and match for correctness of fit rather than perform direct measurement of each part.

When the measurement requirements are stated in terms of the needs of the system, (number of correctly matching parts, number of correctly measured dosimeters, etc.) one can measure success of the measurement effort in terms of closeness to meeting those goals. Measurement efficiency is thus judged in terms of the output of the organization rather than by the count of the number of significant digits. Also, one needs this measure of performance of the measurement effort to be able to identify those areas which need improvement.
Examples of Measurement Assurance Programs in NBS Measurements

Two easily described measurement assurance programs are those in mass and length. In routine calibration, a check standard is included with each set of weighings and process control is maintained by monitoring the value obtained for the check standard and of the random error from the least squares analysis \[8, 9\]. Control charts have been maintained since 1963. In the calibration of gage blocks, similar process control has been maintained since 1962 on both the interferometric process by which the assignment of length to the NBS master gage blocks is done and on the comparator process by which length values are transferred to customer gage blocks. \[1, 7\]

Similar programs are in effect in all divisions, but not all quantities involved in calibration have a formal program worthy of the name, measurement assurance.

Examples of Measurement Assurance Programs At Other Laboratories

Only two examples of measurement assurance programs at other laboratories have ever been reported. One at Autonetics [3] in length and one at Mounds Laboratory in mass. Once the mass measurement system for UF6 is underway as part of the Safeguards program, NBS will be able to document the efficacy of the approach in practical measurement.

The NBS Measurement Assurance Programs Offered As A Part Of Our Calibration Service

Measurement Assurance Programs are listed as a calibration service in mass, volt, resistance, capacitance, voltage ratio, watthour meters, platinum resistance thermometry, and laser power. These are designed to measure the offset of measurement processes for the calibration of standards by other standards laboratories. These are applicable only to those laboratories who maintain and calibrate standards in the same manner as NBS. [See 11, 5, 13.]

These procedures enable a laboratory to determine the offset between its process of calibrating standards and that of NBS.

Need For Measurement Assurance Program For Practical Measurement

The UF6 cylinder program for Safeguards [10] is an example of NBS' service in providing a direct method for measuring the offset of practical measurement processes from that accepted as correct, namely mass measurement by NBS. Investigation of the need and possible mechanisms or artifacts for monitoring the offset of practical measurements in quantities such as voltage, resistance, length, radioactivity is underway. (For examples of the application of these principles to sound level meters, see [5].)
In personnel dosimetry procedures are being worked out [14] to monitor the output of firms providing such services. In this case, a table of allowable limits of uncertainty are based on physiological considerations. Process parameters are to be determined by an initial study. Routine monitoring will be used to confirm that the process is "in control" at those levels, otherwise the parameters are redetermined ab initio. These "consistency" or "in control" criteria replace the usual one-time round robin approach. The amount of effort needed to establish this predictability is a function of the risk and costs of wrong decisions.

In industrial measurement we could ask

If some critical measurements on the production line were repeated would the two measurements agree?

How much bad material is passed, or good material rejected because of errors in measurement?

To those who have not properly answered these questions, dollar savings and improved product quality are possible without redesign or changes in production procedures.

Is our faith in instruments justified? Implicit faith in the correctness of instruments means that product variability (as determined by these instruments) is attributed to variability in components, raw materials or even poor design. One wonders how many times this has led to expensive changes in production procedures without apparent improvement because the variability actually arose in the measurements themselves.

How often has the installation and methods of use degraded the output of an instrument capable of much more accuracy than is required when handled properly? Without some surveillance of the actual measurements, one would never know.

One wonders how often a product is redesigned because measurement error has led to the decision that the product does not conform to specifications.

The result of this look at measurement is measurement assurance--the quality control of measurement. If adequate control exists, then one can look elsewhere for improvements in the product line. If it does not, then one has the possibility of savings without changing production procedures.

Some form of redundancy must be built into the process to answer these questions.
References


COMMITTEE CHAIRMEN

VP Administration - Jim Valentino
1A
Meetings and Programs
Sam L. Davidson
Schlumberger Well Services
500 Gulf Freeway
Box 2175
Houston, Texas 77001
(713) 928-6570

1B
Honors and Awards
Douglas Dow
Lockheed-California Company
D/57-47, Bldg. 322, Plant B-3
P. O. Box 551
Burbank, California 91520
(213) 847-5095

1C
Education and Training
Hank Daceman
H. L. D. Associates
390 Meadow Brook Road
North Wales, Pennsylvania 19454
(215) 699-9200

VP Lab Management & Operations - Dean Brunsgart
3A
Calibration System Management
George Rice
D120 031 HCO2
Rockwell-Autonetics
3370 Miraloma Avenue
Anaheim, California 92803
(714) 632-2885

3B
Measurement Assurance
Gary Davidson
S 2718
TRW DSSG
One Space Park
Redondo Beach, California 90278
(213) 535-1684

3C
Product Design & Specification
Charles (Chuck) N. Corbridge
Tektronix, Inc.
MS 58-188
P. O. Box 500
Beaverton, Oregon 97077
(503) 644-0161, Ext. 7880

3D
Calibration Laboratory Automation
R. B. (Pete) England
General Dynamics, Pomona
Mail Zone 6-22
P. O. Box 2507
Pomona, California 91766
(714) 629-5111, Ext. 4312

VP Measurement Requirements - Graham Cameron
2A
National Measurement Requirements
Frank Flynn
Department of the Air Force
HQ Aerospace Guidance & Metro Center
Newark Air Force Station, Ohio 43055
(614) 522-7544

2B
Laboratory Evaluation
Dennis Gallagher
Leeds and Northrup Company
Summeytown Pike
North Wales, Pennsylvania 19454
(215) 643-2000, Ext. 694

2C
Biomedical Electrical Safety Standards
Andrew H. Dickson
Varian Radiation Division
611 Hansen Way
Palo Alto, California 94303
(415) 493-4000, Ext. 3403

VP Communications & Marketing - John Lee
4A
Newsletter
Willbur Anson, 276.02
National Bureau of Standards
Boulder, CO 80302
(303) 499-1000, Ext. 3989

4B
Information & Directory
James W. Gilbert
Automation Industries, Inc.
Vitro Laboratories Division
14000 Georgia Avenue
Silver Spring, Maryland 20910
(301) 871-2165

4C
Recommended Practices
Bob Weber
Lockheed Missiles and Space Company
1111 Lockheed Way
Dept. 0/48-64, Bldg. 151
Sunnyvale, California 94088
(408) 742-2957