Each year the Executive Vice President of NCSL has the responsibility to examine the organization, assess its mission, and develop a long range plan to be initiated in his/her year as president. The purpose of this activity is to set goals, objectives, and direction, and meet the demands of an ever-changing environment. It also positions NCSL in a proactive versus a reactive mode of operation.

MISSION OF THE ORGANIZATION

Although we have seen a continual expansion and broadening, the mission of the organization remains much the same as it did when it was formed in 1961. The principal missions of the organization are:

• Promote cooperative efforts toward solving the common problems faced by its member organizations.
• Collect and disseminate relative information to its member organizations.
• Form consensus and/or opinion, for all or segments of its members, when requested by outside organizations & government bodies, that will serve all or segments of its member organizations.
• Serve as an intermediary between the National Bureau of Standards and the Metrology community.

• Advance "State-of-the-art" Metrology and related activities, both managerial and technical.
• Provide liaison to and from technical societies, trade associations, educational institutions, and other organizations or activities that have common interest.
• Provide recommended practices related to activities of its members.
• Provide a forum to accomplish the mission of NCSL through regional and sectional meetings, conferences, committees, and publications.

1988 KEY INITIATIVES

The mission of the organization tells us who we are. Once the mission is known the past can be assessed and the future planned. Ten key initiatives for 1988 are:

1. Organize the annual conference methods, operation, and organization in a manner to provide year-to-year continuity and improve the event.
2. Spend a significant portion of the agenda at the April board meeting to address the goals and objectives of the organization and long range planning.
3. Identify and explore increased interface with congressional committees through promotion of NCSL resources & knowledge.
4. Plan, initiate, and manage experiments(s) that allows member organizations to assess their measurement competence. These experiments would be similar to the so called "round robin" experiments that NCSL conducted in the '60s.
5. Add and staff the following committees, subcommittees, and ad-hoc committees:
   a. Calibration Procedures Committee. To recommend methodology, practices, and updating RP-3 as its primary goal. Secondary goals would be related to workshops, identification of novel calibration techniques, methods of utilizing manufacturers procedures, etc.

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EDITOR'S MESSAGE

WILDHACK AFTERMATH

The January issue was definitely not my finest hour. First off, a sharp-eyed reader noted that something was out of order on Andy Dunn's article and Andy determined that pages 31 and 32 were reversed. Then I got a copy back from a reader that was totally missing 4 pages around 15 and 66. And the printer missed the print run by 200 copies. Can this have anything to do with winning the Wildhack Award which should reward competence and skill? That's embarrassing, but I suppose such lightning strikes of errors will continue to happen. Fortunately for me, no one can complain very much because no one else wants this job.

GOOD-WORK DEPARTMENT

Last issue was bulging as most could see. I had to leave out 3 interesting reports that Bob Willett submitted from Dallas. Although this was regionally generated, it had national if not international significance, so I've printed the Measurements Capability Integrity Activity project on pp. 5, and another survey on NCSL, Benefits, pg. 67, and an accreditation report on pg. 68.

Bob has been a tireless worker for NCSL, and the growth of the Dallas area attests to that. His regional leadership ranks with our best, and his years of work on the RP for specifications shouldn't go unrecognized. Bob, here's to you and Rockwell for their support over the years.

NEWSLETTER VOLUNTEERS

Well, nice things do happen to those who wait! Two volunteers have stepped forward to help me edit the Newsletter:

1. Jeff Reid of Unidynamics/Phoenix, will be editing Committee News, Lab Tours, and Someone You Should Know.

2. Nancy Thomas of Hewlett-Packard will be doing the Regional Reports.

For that nice action, they get their names attached to the masthead at the left. Anyone else who likes to see their name in genuine print can likewise send in their name.

John L. Minck, Editor
THE MSC WOODINGTON AWARD - 1988
ALGIE LANCE - TRW (DECEASED DEC. 1, 1987)

Woodington Award accepted by son, Mark Lance, John Schultz presenting.

THE WOODINGTON AWARD

As a memorial to Andrew J. Woodington, this award is the measurement community's recognition for outstanding contributions by an individual who represents the highest level of professionalism and dedication in the field of metrology. The award consists of an appropriately inscribed plaque and an honorarium of $500.00.

This year's Woodington award recipient has distinguished himself as a true professional in the field of metrology in the tradition of Andy Woodington.

For his exceptional qualities, it is the unanimous decision of the Board of Directors of MSC to confer the Woodington Award to Mr. Algie Lance.

It is with deep regret & sorrow that I must inform you that Algie Lance is not with us today. He passed away due to cancer in December, 1987.

His son Mark is here today to receive his father's award.

Mark, it is my privilege as Chairman of the Measurement Science Conference to present to you your father's award.

ALGIE LANCE

Algie Lance was a Senior Scientist at the TRW Metrology Laboratory in Redondo Beach, California. He been instrumental in providing technical leadership for conceptual design and development of RF and Microwave Systems in support of Metrology disciplines, and represented the TRW Metrology nationally and internationally in the measurement science community.

His professional career began in 1951, some 36 years ago where he was an Electronic Instructor at Western Electric, teaching Radars/ Missile Systems and Electronic Circuits Analysis courses. In 1952, he was employed by General Electric Company in Utica, New York, where he was involved in the design and development of analog/digital coding and decoding equipment for communications and radar systems.

Starting in 1955, Algie Lance joined Hughes Aircraft Company as a Standards Engineer in the Primary Standards Laboratory where he designed and developed microwave measurements and calibration systems in the various microwave measurement disciplines.

Since 1969, Algie Lance was employed by TRW Electronics and Defense, Redondo Beach, California as a Section Head responsible for the RF & Microwave Standards Laboratory, Low Frequency and DC Standards Laboratory, and the General Instrumentation Laboratory. His recent position was as a Senior Scientist of the TRW Metrology Laboratory.

Mr. Lance was instrumental in establishing the TRW Metrology microwave measurement capabilities as an integral support of TRW High Technology Laboratories. These requirements for advanced measurement capabilities led to close cooperative working relationships with personnel at the National Bureau of Standards, research laboratories, academia, and leading microwave instrumentation companies. Algie was well known for his support of NBS as a National Resource and for his cooperative work with members of the microwave community.

Mr. Lance taught microwave measurements at Los Angeles Trade-Technical College, Santa Monica College, and Pierce College, and had a “Lifetime” teaching credential in the State of California.


(continued on page 10)
EDITOR'S NOTE:
The Board Meeting for late February occurred too late to meet my editorial close. It was caused partly by the fact that "Smitty" Smith submitted his resignation from NCSL and GE/RCA. Because of this, he naturally had many other matters to tend to.

There was a photographic record of the event however, as shown by this large turnout in northern Nevada. Pretty Impressive.

President Gary Davidson presents a certificate of appreciation to Marilyn Ross, NCSL Canadian Section Secretary.

Past President Ed Nemeroff (L), President Gary Davidson, and Executive Vice President Del Caldwell (R).

From left to right – Ed Nemeroff, Selwyn "Smitty" Smith, Gary Davidson. Smitty resigned as NCSL Secretary in conjunction with an unexpected retirement from GE/RCA Solid State.

Ed Nemeroff (R) passes gavel to Gary Davidson.
MEASUREMENT CAPABILITY INTEGRITY ACTIVITY (MCIA) FOR VSWR AND INSERTION LOSS IN NCSL REGION 6 CENTRAL SECTION (DALLAS)

C.W. Hancock, Weinschel Engineering

INTRODUCTION

Differing measuring practices, even within the same organization, may lead to unacceptable variances if all sources of error are not properly accounted for and proper measuring techniques employed. It is also important to not only maintain the calibration current on all test instruments, but also to ensure that any microwave accessories used in the test set-up are not damaged or worn out.

Clearly, most organizations have in place a calibration program to maintain all equipment within specification. However, a clear understanding of errors involved in making a measurement may not always be present. Also, the maintenance of accessories in not always carried out as frequently as may really be necessary. In addition, the same measurement techniques are not always universally employed.

This can lead to a number of difficulties, not the least of which is where a supplier and customer obtain different and conflicting measurement results on the same component.

A number of methods are used to maintain consistency among measuring stations. These include the use of check standards which are routinely measured on each system and results compared thereby gradually building up a history of each set-up and/or operator.

This method does not, of course, provide traceability to a National Standards Laboratory, but it most certainly allows a means for comparison. In addition, the measurement services at the National Bureau of Standards for VSWR and insertion loss are very expensive and are not universally used, particularly in smaller companies. So the check standard method of verifying consistency is an even more valuable tool.

This report deals with a "Measurement Capability Integrity Activity" (MCIA) conceived by the Dallas-Fort Worth Central Section of the National Conference of Standards Laboratories.

MCIA

The purpose of this activity was primarily to establish communication between organizations by means of measurements taken on a common set of stable, precision artifacts. These artifacts were well characterized by a pivot laboratory (Weinschel Engineering), then measured in turn by the participants. Participants were also requested to provide an estimated uncertainty for their measurements. The data was collected and the results plotted by a third party (Texas A&M). Analysis and interpretation of the results were left to the individual participants.

At all stages, participants were requested to measure connector setback to prevent damage to the artifacts. Improper setback is also a potential cause for measurement inaccuracies.

ARTIFACTS

Measurement of VSWR was the primary thrust of this activity with measurement of attenuation secondary.

The basis for the set of artifacts was a set of quality Weinschel attenuators in 7mm, type N and SMA connector styles. The nominal values for these attenuators were chosen so that when used with shorted or open circuit terminations a nominal VSWR of 1.1, 1.2, 1.3 or 1.5 was achieved. A 20 and 60 dB attenuator in each connector style was also included for use in insertion loss comparisons. Terminations in each connector style and sex were also included. Shorts and shielded open circuits were added at a later date.

ACTIVITY REPORT

At the start of the program a number of problems were encountered. These were due, in part, to bad communication but also the lack of shorts and open circuits in the set of artifacts. Delays occurred and also data taken at an early stage did not allow for sensible comparison since different short and open circuits were used at each organization. This was recognized and corrected, thereby providing a set of repeatable artifacts.

It was the original intent for the participants to measure only those artifacts of particular interest. However, the diversity of the kit appears to have caused some to shy away from conducting any measurements. Indeed, to measure all the artifacts within the kit requires in excess of 40 hours steady effort. It is easy to see where, in today's economy, this activity can easily sink to a low priority status. However, if participants had merely taken measurements on one connector style, for instance, these measurements could have been accomplished in an hour or so.

As it turns out, data was only taken by three organizations and a complete set was only available from two. It is difficult to draw conclusions from such a small data set, although it is fair
to say that reasonable agreement was achieved. Figure 1 through 3 show some of the data taken.

It is interesting to note that a single artifact when terminated with either a short or open circuit, yielded a wide range of VSWR. This means that a single artifact would be useful to assess the performance of a measuring system over, say, a 1.03 to 1.38 range. An example is shown in Figure 1. Moreover, the fast moving cyclic nature of such an artifact represents a particularly useful check standard because any discrepancies are easily highlighted.

The stability of the artifacts was evaluated at Weinschel by complete characterization of the kits on two occasions. First, in November, 1985, and then again in May, 1986. Excellent agreement was obtained. To guarantee the validity of the data, the measurements were repeated several times on different measurement systems including a vector corrected system based on the Weinschel Model VM-4B with phase option and on a swept slotted line system. Final data presented for comparison was taken on the VM-4B system because it allowed for easier manipulation of the results. Some of the results taken at Weinschel are shown in Figures 4 through 7.

**CONCLUSION**

The main lesson to be learned from this activity is that as configured it was far too ambitious. However, the measurements made by participants were in quite good agreement. This suggests that artifacts such as those used in the kits are useful as "check standards" either within an organization or for exchange between organizations. They may certainly be used as an alternative to NBS calibration especially in small organizations.

A single artifact with shorted or open termination displays a wide range of VSWR of a cyclic nature. This allows an excellent opportunity for clearly identifying potential or real problems in measuring systems.

**ACKNOWLEDGEMENT**

Without the continuing efforts of Bob Willett of Rockwell Collins and Harvey Evans of Scientific Devices, this activity would not have been completed.

C.W. Hancock
Director of Engineering
Weinschel Engineering
Gaithersburg, Maryland 20877
(301) 948-3434
MODEL 1-10.5, S/N AG4310, Kit CCN #55-193
VSWR N-type MALE (SHORTED TERMINATION)

VSWR

1.4
1.3
1.2
1.1
1.0

2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Frequency (GHz)

FIGURE 4

MODEL 3M-7, S/N DF766, Kit CCN #55-193
VSWR SMA MALE (SHORTED TERMINATION)

VSWR

1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0

2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Frequency (GHz)

FIGURE 5
MODEL 17-7, S/N AG4279, Kit CCN #55-193
VSWR 7 mm (MATCHED TERMINATION)

MODEL 3M-9, S/N DF771, Kit CCN #55-193
VSWR SMA MALE (OPEN TERMINATION)
POSTSCRIPT

SUBJECT: Central Section Coordinator Commentary on the MICA Projects of Region 6 Central Section

My appreciation and thanks to Weinschel Engineering and particularly Chris Hancock for his support of the MICA Pilot Project. Chris picked up the responsibility late in the project. His cooperation and support was excellent in trying times when it would have been much easier to say, "The heck-with-it" and maybe it will go away. Fortunately, Chris was able to support the April Section Meeting and write the summary.

In retrospect, the MICA Pilot Project was a good idea, but success was highly dependent on individuals, their time, dedication, understanding, and communication activities. In these times when organizations are trying to do more in less time with less people and money, and people are changing jobs more frequently, the MICA became a burden to those involved.

The purpose of this MICA was to access this approach as a viable process for verifying a measurement systems expected results. It was not suggested as a replacement for traditional traceability schemes to NBS. Although, when this was started, NBS services costs were prohibitive and were predictably going to get even higher.

Our original objective was to 1) Utilize a test equipment and measurement oriented manufacturer as the pivot laboratory; 2) allow the participant organization flexibility to measure the minimum that they need, but in return provide high quality artifacts, instructions documentation, and results data in graphic Youden diagram format and within four to six weeks of their measurements. This could apply and appeal to the large corporation or the small business with varying requirements of measurement capabilities.

In summary, the biggest problem occurred with the task/function of third-party neutral organization whose job was to collect data from the participants and pivot lab and plot the Youden diagrams. Especially, the work of taking the data sets and converting them accurately to the Youden diagram was a major hurdle. In other words, the results data was not available to the participant in a timely manner. The college or university seemed like the most logical place and environment to accomplish the confidential/data task, but in this case, it wasn't due to manning, funding, and technical limitations.

There was no small business participation, perhaps because they were not comfortable with the NCSL or thought they were at risk, etc. The large corporations that participated had mixed emotions about the direct benefit of this MICA because the results data was so late.

Even though four other organizations were signed up to participate, the pilot MICA of RF/uWave VSWR was terminated. No one was willing and able to serve as the third-party data coordinator and the remaining organizations contacted said they didn't have the time, etc. to participate in the present business environment.

In addition to the data intensive RF/uWave VSWR/Loss MICA, the Section was also planning a similar activity for power measurements with optical fiber transmission medium. We had been through the TE manufacturer coordination stage (Anritsu), project description, artifact preferences, etc. stages when three of the four major organizations in the area transferred the participant groups to other locations. This project has also been cancelled for lack of interest and participants. My thanks and apologies to Anritsu personnel for their interest, work, and patience during the communication and planning stages.

I and NCSL appreciate the effort and time that both Weinschel and Anritsu and their local representatives have put into the pilot MICA projects of Region 6.

R. B. Willett

ALGIE LANCE (continued from page 3)

Algie Lance had over 30 papers published and presented at MSC, IEEE, PMA, and other professional meetings, international conferences and trade journal. This includes microwave measurements and calibration, theory and applications on Power Equations, Power Measurements, Phase Noise Measurements, Thermal Noise Measurements, Directional Couplers, Six-Ports, Automatic Network Analyzers, Phase Shift Measurements, and Measurement Uncertainty.

Mr. Lance was a Senior Member of IEEE; Served on the IEEE Instrumentation and Measurement Society Administrative Committee; Senior Member of PMA; Senior Member of American Defense Preparedness Association; and Member of the Old Crows.

Algie Lance received the "IEEE Career Award" in 1984 for his contributions in the field of Automated Measurement Systems by the IEEE Automatic RF Technique Group of the Microwave Theory and Technique Society. He had also received several commendations for design/development modification of microwave measurement systems by TRW.
Butler County Community College is in a growth process by expanding facilities and purchasing equipment. A new building with controlled environment laboratories is in the planning stages.

Metrology faculty are developing new experiments and instrumentation lists for the Metrology program. Equipment needs are greatest in the areas of chemical, instrumentation, electrical metrology, and microcomputers. Additional experiments in viscosity, humidity measurements, acoustic and vibration levels, nuclear magnetic resource, differential scanning colorimetry, radiation, x-ray and scanning electron microscopy (SEM) are being proposed for the program.

Metrology experts are invited to submit suggestions about specific laboratory experiments and procedures to either Lynn Thompson or Dr. Drum. The Metrology faculty will evaluate the importance of each experiment and determine whether we can implement it. The faculty appreciate the assistance of scientists from the National Bureau of Standards, Industry Metrology laboratories and consultants during the development of laboratory experiments and equipment purchases. Instrumentation gifts from industry are always deeply appreciated. Thank you for your support in a variety of ways.

The College offers a number of workshops, seminars, and other training programs for industry and the Department of Defense. Training programs presented during the past year include Statistical Process Control, Metrology for Technicians (Fluke Electronics Instrumentation), Non-destructive Testing, Pressure and Vacuum Measurements, Electrical and Temperature Measurements, Gage Blocks, and Productivity and Quality Control. As before, the Technology Division will offer seminars in Metrology topics during the summer months. If you are interested in either offering or attending a Metrology training seminar at the College, please contact us.

Butler County Community College will have 22 students available for summer internships beginning May 23, 1988. All students will be available for permanent positions in August, 1988.

A brief biography of each member of the class is provided below. Interested firms should contact Mrs. Lynn Thompson at (412) 287-8711, ext. 288, or (412) 285-4807, for further information.

Richard Checkan
Alissa M. Conklin

Checkan: I would like to obtain a metrology position in either chemical, physical or dimensional metrology. I prefer employment in a chemical Metrology lab where I could apply the knowledge that I have obtained, to perform the measurement needs of my employer. I have no geographic preference for a job location.

Conklin: I am anxious to pursue a career in chemical or dimensional metrology, preferably in research and development. I have a GPA of 4.0 in metrology and I am confident that the theory and lab skills I have acquired will allow me to meet the needs of my employer. I plan to continue my formal education by attending night school. Although I will consider relocation for the right company, a position in the North or mideastern United States is desired.

Al Cooper
Michael Denny

Cooper: I pursued my love for science and mathematics through the field of Metrology while maintaining a 4.0 GPA.
Metrology Talent

As an adaptive self-starter, I am looking for a challenging position where diverse talents are needed. I have an aptitude for digital electronics and a professional interest in R & D, electronics, optics, and all forms of automated systems as they relate to the field of Metrology. I feel my versatility will make a welcome addition to any company. In consideration of a permanent position, my family and I are favorably disposed to relocation.

Denny: I am anxious to acquire an entry-level position in the electrical, optical, dimensional or chemical fields of Metrology. From my studies, I feel confident that I can adequately complete precision measurements in these areas. I am eager to obtain an internship and a possible full-time position after the completion of the curriculum in May. The Presidency of the Metrology Club has taught me to be responsible, organized, ambitious and to work productively with others. While working, I plan to further my education to refine my knowledge in the field of Metrology. I have no geographical preference for a job location.

Gonda: I am interested in obtaining an entry-level position in fluids, temperature, dimensional or chemical Metrology. I have maintained a 3.75 GPA in Metrology and I would enjoy enhancing my knowledge with practical experience.

Gray: I am very interested in an entry-level chemistry laboratory position with an organization concerned with the environmental pollution of our water supply. I am eager to learn of job opportunities in my career field. I have performed 25 laboratory experiments involving chemical testing, calibration of laboratory equipment and, determination of metals and organics. My analytical skills and writing ability have been developed through weekly laboratory reports. Please send information on your Company (as it relates to chemical testing) to 206 Litman Road, Apartment #4B, Butler, PA 16001. This information will help me determine where my qualifications can be used in your Company. Thank you.

Grosclaude: My interests lie in temperature, pressure, vacuum, and dimensional. I am anxious to work with others who can enhance my perception of the Metrology field. I wish to develop my career interests in a research and development field. I have no preference for a geographical location.

Hartzel: I would like to obtain a position in a laboratory using my knowledge acquired in Metrology in the fields of Electronics, Microprocessors and Dimensional. I am competitive in the sense that I'm capable of working in a group as a team or alone to achieve proper results. I would like to acquire a job somewhere on the East coast. I will be available for employment in August, 1988 following completion of summer practicum.

Kline: I am seeking employment in the Electrical, Digital, Microprocessing and/or Optical fields of Metrology. I am enthusiastic about using my skills to achieve accurate results in a precision industry and am willing to relocate anywhere.

Lapen: I am eager to acquire a position in the field of Metrology or other related field. I am most interested in the electrical, optical and dimensional aspects of this field and I feel that I am more that capable of performing my duties in these areas. I am looking forward to working with and
learning from individuals that are experienced in this field. I am very confident that I can apply the measurement skills that I have learned from this program in a professional, responsible manner that will prove valuable to any employer. I enjoy working in the laboratory environment, solving problems and perform best in hands-on situations. For the past two years, I have funded my education by being the owner and manager of a small thoroughbred horse farm. I am willing to relocate anywhere in North America.

Doug LeViere

LeViere: I am currently working in the quality assurance lab of the Calgon Corporation as a Laboratory Technician. I plan to further my education in the Chemistry field.

Tom McConnell

McConnell: I desire a position in a Standards Laboratory, which would allow my versatility to be utilized. I have eight (8) years experience directly with Metrology and six (6) years of troubleshooting, repair and calibration of special weapons systems. The extensive schooling at Butler County Community College has increased my overall understanding, plus opened new areas of Metrology to me. I would like to continue my education in the areas of physics and natural sciences. I have no geographical preference and overseas would be fine.

Jenifer L. Mrochek

Mrochek: I am anxious to pursue a challenging career in the chemical/medical areas of Metrology. I have a Bachelor of Arts degree in Business Administration from Grove City College, and would like the opportunity to use my management, laboratory and calibrating skills in a technology driven company. I am willing to relocate and have no geographical preference.

Kimberley Reiff

Reiff: As a metrologist, I would prefer a position in analytical chemistry, digital electronics or optics dealing with research and development. I feel confident that Laboratory work is my strongest point. My present GPA in Metrology is 3.00. I am a member of the Metrology Club and am also a member of the National Honor Society. My awards include a college scholarship and an AAUW scholarship. I am willing to relocate but prefer the Eastern United States.

Shawn Rider

Rider: I am presently seeking an entry-level position in the Metrology field. I would like to be able to put my learning and valuable experience that I have gained through my course of study at Butler County Community College to good use. My main goal is to receive a position that involves my interests of optics, chemistry, electrical and dimensional metrology, preferably in research and development. I would be willing to relocate anywhere in the northeastern United States in order to achieve the goals that I have set for myself. I believe that Metrology will help our country become more competitive in the world market place.
Rosenberg: My name is John A. Rosenberg. I am 40 years old. I am seeking employment with a company where I can utilize my knowledge of Metrology in the physical, electrical and chemical fields. I am currently employed full-time as a laborer at Armco, Inc. in Butler, PA while completing the Metrology Program. I have no geographical preference.

Schoettker: Chemical, Physical and Dimensional Metrology have become my main areas of interest. I am eager to pursue a career in one of these areas. I have acquired a thorough understanding of Metrology which is apparent by my GPA of 4.0. I believe the Metrology Program has adequately prepared me for employment through lectures and labs. I am looking forward to a challenging and rewarding career in precision measurement.

Shaffer: I particularly enjoyed the chemical analysis section of the metrology Program. My speech and debate classes have given me the ability to communicate well with others. A position as a field representative or troubleshooter for a company is my desired goal.

Slaughenhoupt: I am interested in any job in the field of Metrology. I would appreciate any information you can provide that will aid me in obtaining either a full-time job or temporary job by which I can complete an internship. I would prefer a job in the Eastern part of the United States.

Staff: I would like a Metrology position working in dimensional, electrical, or optical areas. I am anxious to apply the knowledge and skills that I have acquired. My GPA is 3.65. I have no geographic preference.

Wiest: I am looking for an entry-level position in Metrology in the Eastern or Southeastern region of the United States. I feel very confident that I am qualified for a job of this type. My education in Metrology is supplemented by three (3) years of Metallurgy at Penn State University. I am available for either permanent work or an internship which I must complete to receive my degree.

SENIOR MEASUREMENT SCIENCE PERSON AVAILABLE

A senior metrology person working in Europe will be taking a sabbatical in the United States from Summer 1988 to Summer 1989 and wishes to seek a similar position with a US company for that period.

The first preference is in the calibration field, with the second preference in a research group using lasers in different types of measurements.

The person has about 10 years of experience, mostly in physical calibration and with responsibility for computerizing automatic calibration measurement and analysis of results.

Editor's Note: I have a copy of the resume and will send it to anyone with interest.
STATEMENT OF UNCERTAINTIES - AN ALTERNATE VIEW

by

A. F. Dunn
Measurements International Limited
Prescott, Ontario, Canada

INTRODUCTION

The NCSL Newsletter Volume 27, No. 4, p 52-62 dated October, 1987 published three reports on Meetings on Measurement Uncertainties. It appears there is a major divergence of views concerning what to do about assessing uncertainties in a sequence of measurements.

Despite some of the conflicting views which may or may not be based on a technical or a theoretical basis, there are other aspects of the published manuscripts which causes grave concern such as:

a. the apparent refusal by some to consider any names other than random and systematic to describe errors and/or uncertainties. It has also been suggested that type A and type B (suggested by BIPM) have become "cast in concrete".

b. one form of reaction to any change in thinking was that "acceptance of the BIPM recommendations would require costly and confusing conversion."

c. another reaction appears to be "this BIPM methodology has the potential to alter our whole approach to the subject of measurement uncertainty if it is ever applied to data outside that obtained in the calibration laboratory."

These examples of what appear to be intransigent positions on various sides of very complicated and conflicting matter which should be amenable to a technical solution, leads one to believe there is little hope of a resolution at this stage.

In addition, this spokesman is not certain that the problems faced by many industrial laboratories and the industries they support are even being addressed. It had been felt that when the problems of assessing the uncertainties in the determination of the fundamental constants or the realizations of the base and derived units of measurement in the various national laboratories could be solved and accepted internationally, most of the problems associated with uncertainties would be solved by extension. Such does not appear to be the case.

CALIBRATION LABORATORY REQUIREMENTS

In any calibration laboratory operation within industry, it is necessary that the laboratory take the calibration report data from a hierarchical "senior" laboratory, combine it with the techniques and environmental conditions in their own laboratory and provide a calibration report for use by other laboratories or production functions which is understandable by all involved. The same procedure comes in to play when one considers measurement techniques, or instruments to be used for a measurement, and then make a decision on whether or not such a technique or instrument is adequate for the requirement, when the requirement has been established by other hierarchies. A secondary item of consideration arises when one must make certain measurements in the field and provide an understandable assessment of the new uncertainty involved.

In all cases, it is desirable that a confidence level be used and stated in each report of a value and associated uncertainty. If a 100% confidence level is reported, there must be distinction between the 100% probability confidence level and the 100% worst case uncertainty, and it is to be noted the two are not the same. From a personal point of view, the 95% probability confidence level is preferred, which means that 1 in 20 measurements should be outside the bilateral uncertainty limits reported, and that on occasion one will be a long way outside the limits reported.

CONTRIBUTIONS TO MEASUREMENT UNCERTAINTY

Ordinarily, an expression for the uncertainty of a measurement requires two numbers, one for the offset or bias, and the other indicating its precision. Determination of the precision can readily be accomplished by the usual statistical techniques of repeated measurements, although in most calibration laboratories only one or two measurements are made on any artifact standard. This means that the concept of the standard deviation of the mean and the Student t factor based on degrees of freedom is seldom used, and the (statistical) assessment of the standard deviation of a single measurement based on the normal operation of the equipment when in statistical control is usually adopted.

Arriving at a magnitude for the bias or systematic effect is more difficult, since in any well-conducted measurement the known biases are corrected for and do not contribute to the effect, although there is a residual uncertainty represented by the uncertainties of the correction. Since the exact magnitude of the remaining bias cannot be known, the best that can be done is to estimate a reasonable limit for the magnitudes.

The assignment of limits to the effects of individual sources of possible bias involves knowledge of the theory governing the
measurement, a careful study of the test system and its components, perhaps even the use of alternate methods or systems, and eventually an estimate of the narrowest limit which it is believed would not be exceeded. These limits to the individual sources of bias represent other forms of uncertainty which must be included in the systematic uncertainties.

PRACTICES IN SUMMARIZING UNCERTAINTIES

Once a limit has been assigned to each potential source of a systematic uncertainty, these limits must be combined in such a way as to yield the most meaningful estimate of the total uncertainty coming from the systematic effects. The most pessimistic method of combining systematic error limits by simple addition, whereas a more optimistic method is to combine these by calculating the square root of the sum of squares of the individual elements. The latter method assumes that not all the individual systematic effects will combine in the same direction; there should be some compensation occurring in any natural measurement situation.

A practice that has received some support is to use the square root of the sum of the squares of the contributing elements, but if there are any which are markedly larger than the others, these are summed together and added to the root-sum-square of the remaining ones. Any small ones amongst the individual elements make no difference in either technique. This practice has the advantage that it enables one to achieve just about any figure for the total uncertainty due to the assigned limits of the systematic effects. The fact that there is no justification in statistical theory, and that no probability limits or confidence levels can be logically assigned to the "total" appears to be unimportant.

On the other hand, if the assignment of limits to each individual effect is derived from an "equivalent standard deviation", for which there is some form of justification in statistical theory, then the root-sum-square of the individuals is equivalent to taking the square root of the sum of the individual variances, which again is theoretically justified, leading to a new "equivalent standard deviation" to which a probability limit, or confidence level, can be assigned.

It has been accepted by many that, in a hierarchy of measurements where additional uncertainties are contributed at each stage, the distinction between "random" and "systematic" is lost when one moves from one stage to the next in the chain. This means that whatever uncertainty statements are made in a report, they must be combined into a single statement for understandable use in the next stage of the chain.

As the random uncertainties, or the Type A uncertainties, are naturally expressible as a standard deviation with an associated confidence level (say 95%), then it becomes clear that any expression of a systematic uncertainty, or a Type B uncertainty, should be expressed as an equivalent standard deviation with an associated confidence level. In order to combine the two, the confidence levels must be the same for the combination to have an understandable meaning.

CONCLUSION

It appears that many people have no intention of changing their current practices in order to reach a methodology which can be useful to laboratories throughout the chain, and which can provide understandable information which enables one to make decisions. It is suggested that the various committees and individuals go back to the drawing boards and start thinking about a system which can be useful to a great many more people than appears to be the case today. The ability of one laboratory or individual to understand what another is saying and to make use of the information is of paramount importance.
THE CALIBRATION OF IONIZATION GAUGES USING
THE SPINNING ROTOR GAGE

A Hands-on Workshop Conducted by the National Bureau of
Standards

Session A: May 9-12, 1988
Session B: May 11-13, 1988

Personnel of the Temperature and Pressure Division will be
conducting a two and one-half day workshop on the use of the
spinning rotor (or molecular drag) gauge to calibrate
ionization gauges in the pressure range $10^{-6}$ to $10^{-3}$ Torr
($10^{-4}$ to $10^{-1}$ Pa). There will be one-half day of lecture
followed by demonstrations in the lab, one full day of using
the gauges to perform calibrations, and one-half day of follow-
up discussions, questions, and visits to vacuum facilities. In
order to permit maximum use of the gauges, the number of
participants is kept to four per system (a maximum of sixteen
participants per workshop). The cost of the workshop is
$500.00. Interested parties should contact Sharrill Dittmann
(301) 975-4838 for information or registration.

DALFI, INC. FLOW MEASUREMENT TRAINING
COURSES

Introduction

Liquid and Gas Flowmeters are used in a wide variety of
applications. These flowmeters must be selected carefully and
maintained properly to provide the desired performance. In
addition, they must be calibrated periodically to assure their
continued accuracy. These courses will provide solutions to
these Flow Measurement problems.

All commonly used types of flowmeters will be discussed.
Each will be compared in terms of accuracy, limitations,
maintenance and repairs. Typical applications will be
reviewed. Potential errors will be analyzed. Installation
requirements and troubleshooting will be described and
methods of calibration will be explained.

1988 Course Schedule
Gas Flow Measurement
18-22 July, Fort Collins, Colorado
Liquid Flow Measurement
24-28 October, San Diego, California

Who Should Attend

These Flow Measurement Training Courses will benefit
Managers, Engineers, Designers, Technicians, and Quality
Control personnel who are involved with specifying,
calibrating or using flowmeters. Numerous flow measurement
applications are found in Metrology Laboratories, Field
Calibration, Overhaul Facilities, Repair Shops, Shipboard
Maintenance, Utility Management and others.

Tuition

The Tuition for each five-day training course is $845 per
person. This includes all course materials, a comprehensive
Flow Measurement Handbook and refreshments during class
hours. It does not include meals or hotels.

For Further Information

If you would liked more information, please contact:
Joni Shepard
DALFI, Inc.
10085 Carroll Canyon Road
San Diego, California 92131 – 1107
(619) 578-9500

MEASUREMENT UNCERTAINTY COURSE DATE SET

A five-day, thirty-five hour course given by Rolf B. F.
Schumacher in the systematic assessment, control, and
determination of the magnitude of the elements of
measurement uncertainties as well as the overall uncertainties
of measurements and calibrations, with special emphasis on
the control of measurements and calibrations, with special
emphasis on the control of measurements and calibrations as
repeatable processes.

The course will also show how a program to assure the
systematic determination and control measurement assurance
program can become an integral part of an organization's
total quality program. (See July '87 Newsletter for course
info, page 10.)

Classes
6-10 June 1988, Ottawa, Ontario, Canada.

CONTACT: Marlene Chandler, COAST Quality Metrology
Systems, Inc. (714) 492-6321

TROUBLESHOOTING MICROPROCESSOR-BASED
EQUIPMENT AND DIGITAL DEVICES

Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032,
(800) 247-5239

DATES AND LOCATIONS FOR 1988 SESSIONS

Atlanta, GA – Apr. 12-15
Amberley Suite Hotel
Course Instructor: Duane Eyman has over thirty years of experience in the computer and electronics industry. He is a graduate of the University of Kansas and a former member of the faculty of Pittsburg State University. My Eyman's background includes work on space and aeronautical electronics systems while associated with the Army and Air Force ans an engineer and technician.

CONTACT: Janet McHenry (800) 247-5239

DALFI, INC. MEASUREMENT UNCERTAINTY TRAINING COURSES

Introduction

Measurements are vital to our everyday lives. Our quality of life, health, safety, environment and economy are all influenced on some way by measurements. The accuracy of these measurements may often be an important consideration. To be valid, the accuracy must be traceable to legal or generally recognized standards.

This course will provide instruction in the nature of errors and the methods used to determine the uncertainty of a system or process. Programs for measurement assurance will be discussed as well as methods that can be used to control the quality of a measurement.

Students will work practice problems that are directly related to real measurement and calibration application.

1988 Course Schedule:
Measurement Uncertainty
25-29 April San Diego, California
3-7 October Orlando, Florida

Who Should Attend

This training course will benefit Managers, Engineers, Designers, Technicians and Quality Control personnel who are involved in making measurements, determining system performance, calibration instruments and evaluating system uncertainty and traceability.

Tuition

The Tuition for each five-day training course is $845 per person. This includes all course materials, a comprehensive notebook and refreshments firing the class hours. It does not include meals or hotels.

For Further Information

If you would like more information, please contact:
DALFI, Inc.
10085 Carroll Canyon Road
San Diego, California 92131 – 1107
(619) 578-9500
SEMINARS IN ELECTRICAL METROLOGY
To be held in 1988

A. General Metrology

This 4-day course will provide the laboratory supervisor with a fundamental understanding of electrical metrology. Topics covered include units, measurement uncertainties, reference standards, calculations, lab practices, maintenance of a lab unit and quality manuals. Among those who should attend are lab supervisors, electronics technologists and technicians, electronics engineers, quality assurance personnel and any other individuals involved in electrical measurement or instrument calibration.

Dates: April 11-14; September 12-25.
Fee: C$795.00 (US$695.00), includes all course materials.

B. Measurement Assurance

A 4-day intensive course on the nature of errors in measurement and methods used to determine uncertainties in calibration and systems measurements. Measurement assurance programs will be covered, as well as methods for quality control and assessment of uncertainties. The course will benefit managers, engineers, designers, technicians and quality assurance personnel who are involved in making measurements, determining system performance or evaluating metrological uncertainty.

Dates: May 2-5; October 3-6.
Fee: C$895.00 (US$795.00), includes all course materials.

C. Maintaining the Laboratory Unit of Voltage

This 2-day course will focus on new and proven methods of standard voltage reference maintenance, including standard cells and the 10V Zener reference. Topics dealt will include cell-to-cell comparisons, constant temperature environments, interconnection for elimination of thermal and other extraneous potentials, transportation of standards and factors in Zener reference selection. The course is aimed at lab supervisors, quality assurance managers and others concerned with maintaining electrical lab standards.

Dates: April 25 & 26; May 30 & 31; October 17 & 18.
Fee: C$595.00 (US$495.00), includes all course materials.

For more information, contact Dr. A. F. Dunn, Measurements International Ltd., P.O. Box 2359, Prescott, Ont. Canada KOE 1TO. (613) 925-5934.

GENERAL INFORMATION

All seminars will be conducted by Andrew F. Dunn, Ph.D., P. Eng., FIEEE. Dr. Dunn has over 35 years experience in the field of electrical metrology. He has worked in the Electrical Standards Section of the Division of Physics at the National Research Council of Canada. From 1971 to 1987, he was Chief of that Section. He has authored many papers on electrical metrology, and at NRCC he was responsible for establishing and maintaining electrical measurement standards, developing measurement techniques and supervising an electrical instrument calibration service. His most recent interest is the extension of precision electrical measurements to the industrial environment.

NCSL NEWSLETTER EDITORIAL SCHEDULE FOR 1988

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EDITOR’S NOTE

This schedule is for guidance for anyone who needs to submit material for publication in the Newsletter. You can understand that in a purely voluntary function like this, the Newsletter must be secondary to my regular job. I try to stay on schedule, but there is zero backup, so if I must travel on company business or other, nothing gets done.
Keynote speaker Harry Quong, of NASA reminded us of quality impacts.

Entrance to exhibit was always well filled.

Luncheon speaker, Dr. Jake Sredni, showed how to configure experiments using cake baking as an intriguing example.

How could I avoid showing this logo?

Norm Belecki, NBS, giving a DC tutorial.

A wise man once said "nothing happens until someone sells something." Probably a marketing man.
SOMEONE YOU SHOULD KNOW

Bob Smith
Vice President of Laboratory Management
Metrology Supervisor
Aeronutronic Div. of Ford Aerospace
Newport Beach, CA.

Bob received his B. A. from Hastings College, Hastings Nebraska, with majors in Physics and Mathematics. Immediately upon graduation in 1959 he joined General Dynamics Astronautics in San Diego, starting out on the right foot as an Engineer in the Metrology Lab reporting to Andy Woodington and Hartwell Keith. His primary responsibility at GD was the calibration of Scientific Instruments and Optical Measuring Equipment.

In 1966 Bob joined Aeronutronic as a Senior R & D Engineer in the Metrology Lab again reporting to Hartwell Keith, a past NCSL president. His assignment was to work with Engineering to develop the Infrared Standards required by Metrology to support infrared technology programs at Aeronutronic. He was also assigned the calibration maintenance and development of primary electrical and dimensional standards for the Division.

In 1972 Bob was promoted to Unit Supervisor of the Primary Standards, Physical, and Electronic Measurement group of the Metrology Lab. In 1981 he assumed total management responsibility for the Metrology Laboratory, which included the calibration of production on-site test systems.

From early in his career Bob has been familiar with NCSL and a past chairman of NCSL and one of the individuals who labored to make NCSL a reality and for whom the Measurement Science Conference Woodington Award is named.

Bob has attempted to continue to put the lessons learned through NCSL to work. His company has participated in regional MAP programs for voltage, resistance, and length. With the guidance of a supportive management the MAG (Measurement Assurance Group) was formed as part of the Metrology Function. This group attempts to carry the measurement principles of MAPs to the production line test systems. See Special Test Equipment, Metrology’s Headache, The Measurement Assurance Group Provides Relief, by Kurt K. Krause; 1985 NCSL Workshop & Symposium Proceedings.

Bob has been a member of the AUTOMATIC TEST & CALIBRATION SYSTEM COMMITTEE since 1980, being the coordinator of the NCSL Calculator Tape/Disk Software Exchange Program.

In the fall of 1984 Bob was named coordinator of the Los Angeles Section of Region 8. The L. A. Section meetings have continued to provide a forum for discussion on a variety of current issue topics. Good open dialog has continued with BNS personnel and high attendance and participation has been maintained over the years at these meetings.

Bob resides with his wife Jo in Irvine, CA. They have a daughter, Tobey (no longer at home), and two sons, Kit and Jeremy. Bob, along with Jeremy, has recently developed a special interest in Astronomy.

In July, 1987 he was appointed Director of Region 6 and Region 8, filling an unexpired vacancy on the Board of Directors. He was elected a Vice President beginning in 1988.
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REPORT FROM THE AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION

As we begin a new year, the Association is pleased to report a 55% increase in accreditations during 1987. The Association has changed its logo to "A2LA." The A2LA Board of Directors acted in view of the continuing growth and the need for updating the Bylaws and image of the Association in light of that growth. The annual report and 1988 Directory of Accredited Laboratories will be available next month.

A2LA has entered into a contractual arrangement with the Defense Industrial Supply Center (DISC) to accredit metals testing laboratories in support of DISC procurement requirements.

Peter S. Unger
Manager, Laboratory Accreditation

METALS TEST PROGRAM

The American Association for Laboratory Accreditation (A2LA) today announced that it received a contract from the Defense Industrial Supply Center (DISC) in Philadelphia to "Develop an Accreditation Program for Metals Testing". DISC purchases metal testing services for a variety of military uses throughout the United States. For some time, it has sought to identify competent sources of testing.

A2LA has accredited over 100 testing laboratories in mechanical, chemical and construction-related fields of testing, including some laboratories that do metals testing. The DISC support is intended to enhance and ensure the technical credibility of the program to meet DISC needs. John Locke, President of the Association, explained: "We are pleased to have the opportunity to enhance our existing program for recognizing competent testing laboratories to meet specific Defense Department needs."

ASBESTOS PROGRAM ANNOUNCED

A special program to accredit asbestos laboratories for phase contrast microscopy, polarized light microscopy, scanning electron microscopy and transmission electron microscopy under the environmental program was announced in December. The program takes cognizance of the accreditation alternatives currently being developed by others and offers a substantive laboratory assessment which may be modified in the future when some of the substantive alternatives come into existence. The Asbestos Task Group of the Environmental Advisory Committee has developed a checklist we will use as a basis for assessing the laboratories. We would welcome your recommendations for assessors.

A2LA TRAINING COURSES

The Seminar "What You Should Know About Laboratory Quality Control and Assessment for Environmental Testing" sponsored by A2LA and the Center for Energy and Environmental Management (CEEM) was very successful – there were 63 attendees. Based on the comments received at the course, we will modify the presentation somewhat to stress even more the EPA methods and quality requirements in the methods. Al Liabastre was very effective in bringing this information to the attendees. The seminar will be given again in Houston on March 23 and 24, in Washington, DC (near Dulles airport) on April 19 and 20, and in Chicago on May 12 and 13. A brochure will be supplied on request.

NEW LAB DIRECTORY FROM ASTM

ASTM, the world's largest developer of standard test methods, announced today the publication of the 1988 ASTM Directory of Testing Laboratories. This new edition features 1000 laboratories, the majority located in the U.S. and forty in Canada. Searching is aided by detailed subject and alphabetical indexes.

The laboratories are in the business of performing services for a fee. They are not certified or endorsed by ASTM. The Directory price is $50.00 ($40.00 to ASTM members). Contact: ASTM Customer Service, 1916 Race Street, Philadelphia, PA 19103, (215) 299-5585.

FREE 1988 STANDARDS CATALOG FROM ASTM

A catalog describing the 67 volumes in the 1988 Annual Book of ASTM Standards is available free from ASTM.

ASTM publishes over 8,500 standards in many technical fields, including ferrous and nonferrous metals, energy, environmental analysis, coatings, construction, petroleum, textiles, plastics, medical devices and services, and consumer products.

ASTM standards include specifications, test methods, practices, and terminology. They are used worldwide to facilitate commerce, ensure the quality of commodities, and promote product safety.

The catalog is available from Mrs. Jackie Nolden, ASTM, 1916 Race Street, Philadelphia, PA 19103 (215) 299-5594.
YSI PUBLISHES TEMPERATURE CALIBRATION REFERENCE POSTER MATCHING POINTS ON THE IPTS WITH YSI CALIBRATION APPARATUS

YSI is offering a color reference poster for standards laboratories on primary temperature calibration that highlights YSI apparatus.

On one side of a large thermometer the poster shows the defining and reference points of the International Practical Temperature Scale of 1968. The other side of the thermometer identifies the YSI apparatus for realizing the points between the oxygen boiling point (-182.962°C) and the silver freezing point (961.93°C).

YSI makes the traditional Standard Platinum Resistance Thermometer (SPRT), the world's working standard of temperature, and also manufactures apparatus for calibrating SPRTs according to the IPTS and the International Conference of Weights and Measures (CIPM).

CALL FOR PAPERS, 1989 MEASUREMENT SCIENCE CONFERENCE, JANUARY 26 & 27, 1989

AUTHORS

You are invited to participate in the 1989 conference by presenting an original paper in one of the topics listed or a related subject. Please notify the conference chairman as soon as possible of your interest. The deadline for submitting your abstract of not more than 200 words is April 15, 1988. Please include your name, address, telephone number and a short biographical sketch with your abstract.

SESSION DEVELOPERS

If you are interested in developing a technical session in one of these or a related topic, please notify the conference chairman at the earliest possible time. Send your name, address, telephone number and a short biographical sketch to the conference chairman and indicate your area of interest as soon as possible.

TOPICS INCLUDE

Metrology and Quality Assurance
Process Control/Measurement Control
Productivity and Quality
Propagation of Uncertainties
International Traceability
Developments at NBS
Automation of Calibration
Computer Applications in the Laboratory

Technical Disciplines Including:
  Electro Mechanical
  Dimension/Linear
  Time and Frequency
  Optical Electronics
  Microwave/Millimeter Wave
  DC/Low Frequency
  Statistics

ABSTRACT DEADLINE

April 15, 1988

RESPOND TO

Frank Mendoza, Conference Chairman
TRW S & D
One Space Park, Mail Sta. S-2470
Redondo Beach, CA 90278

NEW FOUR-LANGUAGE DICTIONARY ON MEASUREMENT AND INSTRUMENTATION

The International Measurement Confederation (IMEKO) has published a VOCABULARY OF TERMS in English, German, Russian and French, specifically addressed to the needs of measurement and instrumentation community.
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Editor, Dr. Phil Gerlinde HOFMANN chairs IMEKO'S Technical Committee on Vocabulary and is a linguist on the faculty of Schiller University, Jena, German Democratic Republic, on special assignment to the University of Novi Sad, Yugoslavia.

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1938 – 1988 GOLDEN JUBILEE OF STRAIN GAGES/LOAD CELLS/TURSDUCERS/BrittLe COATINGS

This anniversary, important to the measurement world, is being celebrated at two international congresses:

- June 6-10, 1988
  Western Regional Strain Gage Committee
  Society for Experimental Mechanics
  X1th International Congress
  Portland, Oregon

A 2-day session is being arranged by WRSGC. One day is devoted to the "Early Days", 1938, featuring inventors, developers and pioneers. The second day presents the state-of-the-art in 1988. Co-Chairmen planning the by-invitation-only program represent WRSGC and SEM's Technical Committee on Strain Gages, TCG.

- October 17-, 1988
  International Measurement Confederation
  X11th International Congress
  Instrument Society of America
  43rd Annual Conference & Exhibit
  Houston, Texas

A one-afternoon session sponsored by IMEKO Technical Committees TC-3: Measurement of Force and Mass, and TC-15: Measurements in Experimental Mechanics. Delegates of the 19 member-countries will present the first arrival of these invaluable techniques in their country, the people involved and the projects on which they were used.

CONTACT: Jubilee Coordinator: Peter K. Stein, 5602 E. Monte Rosa, Phoenix, AZ 85018, Phone: (602) 945-4603

CROSS-REFERENCE PARTS NUMBERS

In the 4th Quarter issue of HP's Bench Briefs, there are 24 pages of semi-conductor Hewlett-Packard part numbers referenced to industry generic part numbers as well as reference to JEDEC military numbers.

For your copy, contact: Inquiries Manager, Hewlett-Packard, 1820 Embarcadero Rd., Palo Alto, CA 94303. Ask for pub number 5992-0130.

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BOARD OF DIRECTORS MEETING DATES
April 25-27, 1988
Pine Mountain, GA

August 14 & 19, 1988
Grand Hyatt Hotel, Washington, D.C.

October 24-26, 1988
Santa Fe, New Mexico

April 13-15, 1988
4th International Conference on Metrology and Properties of Engineering Surfaces, National Bureau of Standards, Gaithersburg, Maryland.

April 21-22, 1988
Workshop on Microstructure and Macromolecular Research with Cold Neutrons, National Bureau of Standards, Gaithersburg, Maryland.

April 19-22
IEEE Instrumentations/Measurements Technology Conference (San Diego, CA)
Robert Myers, Los Angeles, CA;
(213) 475-4571

May 2-5, 1988
ISA's Aerospace Industries/Test Measurement Div. 34th International Instrumentation Symposium, at Albuquerque, NM, Call J. Taylor at (818) 357-2281.

May 25-27
IEEE MTT-S International Microwave Symposium (New York, NY)
Charles Buntschuh, Narda Microwave Corp., Hauppauge, NY;
(516) 231-1700

June 7-10, 1988
CEPM '88 - Conference on Precision electromagnetic Measurements to be held at Tsukuba Science City, Japan. Write to: CPEM '88 Secretary, Dr. Toshio Nemoto, c/o Business Center for Academic Societies, Japan Conference Department 40-14, Hongo 2-chome, Bunkyo-ku, Tokyo 113, Japan.

June 20-23, 1988
Tenth Symposium on Thermophysical Properties, National Bureau of Standards, Gaithersburg, Maryland.

July 31 – August 5, 1988

August 14-18, 1988
NCSL 1988 Annual Conference at the Grand Hyatt Hotel, Washington, D.C.

Sept. 29-30, 1988
Equipment Management Forum, Atlanta, GA
Contact: Charlie Sides, Boeing, (206) 773-9944

October 16-21, 1988
ISA/88 International Conference and Exhibit. Astrohall, Houston, TX. For more information call (919) 549-8411

October 16-21, 1988
IMEKO Congress, Houston, TX. For more information call Marie Long, Manager, Meetings ISA, (919) 549-8411.

November 14-17, 1988
5th Environmental Stress Screening Electronic Hardware National Conference, Orlando Marriott. Call (312) 255-1561.

1989 Measurement Science Conference (MSC), to be held at the Anaheim Marriott, Anaheim, CA. To present a paper or get more information contact: Frank Mendoza, Conference Chairman, TRW S&D, One Space Park, MS S-2470, Redondo Beach, CA 90278.

REGIONAL MEETINGS SCHEDULE

REGION 1. Typically holds two (2) meetings per year, a regional business meeting and a technical session. The next meetings are tentatively for April 20, 1988 at Wiltron Inc., and October 19, 1988 at Sanders Associates.

REGION 2. Has two (2) meetings scheduled for 1988: April at Fluke in New Jersey and September at Loral in New York.


REGION 4. Plans are to hold four (4) meetings each year. The next Atlanta Section meeting is scheduled for Mar. 17, 1988 at Northlake Hilton, Atlanta, Georgia. The second meeting will be held at the same place on Sept. 15, 1988. The Central Florida Section will meet on May 18, 1988 at the Holiday Inn International Dr., Orlando, Florida. Their second meeting will be held on Oct. 26, 1988 at the Holiday Inn in Titusville, Florida.

REGION 5. The tentative meeting schedule is as follows:
April 12, Michigan
April 19, Indiana
October 25, No. Ohio
November 8, Indiana
November 15, So. Ohio/KY

REGION 6. The Central (Dallas/Fort Worth) Section (four year schedule): The Wednesday of the first full week of April and November, rotating between Tektronix's, Fluke's and Hewlett-Packard's facilities adjacent to DFW Airport between Dallas and Fort Worth. The dates are:
South Austin Section (three-year schedule): The Thursday of the first full week of Jan., May and Sept. The locations to be determined within a 50 mile radius of Austin. The dates are: 5/5/88, 9/8/88, 1/5/89, 5/11/89, 9/7/89, 1/11/90, 5/10/90, 9/6/90.

REGION 7. All meetings are held in the San Francisco Bay Area. The next meeting will be held on May 5, 1988 at Ampex, Redwood City, CA. Topics will include: Lighting Positioning and Software/Firmware Support for Test Equipment. The Fall meeting will be held on November 3, 1988, at Hewlett-Packard Product Support Div., Mountain View, CA.

REGION 8. 1988 Schedule of Events: The Los Angeles Section has recently split into what will be called the "Los Angeles/Valley" Section and the "Los Angeles/Orange Country" Section. Each section met in early March and they will hold a joint meeting at the Proud Bird restaurant on Sept. 21, 1988. The Phoenix/Tucson Section will meet on April 28th in Phoenix, AZ following the NCSL Board meeting. There will be a joint NCSL, ASQC, PMA Section meeting on May 17th in San Diego. The Phoenix/Rucson section will again meet in Tucson on October 27th. And on December 7th the San Diego section will meet in San Diego.

REGION 9. Plans to hold two meeting each year. The next meeting is tentatively scheduled for April 6, 1988 at Tri Cities Washington. The fall meeting is planned for October 5, 1988 and it will be held in the Seattle area.

REGION 10. (INTERNATIONAL) Plan to hold a meeting at the Annual Conference in August of 1988 at Washington, DC.

REGION 11. 1988 Schedule of Events:
March 22, St. Louis
April 14, Chicago
April 19, Twin Cities
May 10, Iowa
October 11, Twin Cities
October 20, Chicago

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Journal of Research of the National Bureau of Standards

Two Theories of Experimental Error

The first four pages of this article were reprinted in the NCSL Newsletter of January 1988.

2.1 The Formulation of the Orthodox Distinction Between Systematic and Random Uncertainties

There are three possible approaches to the classification of errors as systematic or random. Definitions may be cast in terms of . . .

1) how they would behave if an experiment were repeated (e.g., in terms of the forms which their distributions would take),
2) how their causes would behave upon repetition of the experiment or the nature of their causes (e.g.,
scale errors, rounding, fluctuations of one kind or another, mistakes), and
3) the way they are treated (e.g., by statistical means or on the basis of a theoretical estimate).

Confusion often arises in elementary accounts of the nature of errors because these various approaches are not clearly distinguished. In this section the classification of errors will be based initially on their behavior when an experiment or, perhaps, some associated “trial,” is repeated [approach 1] above. The combination of uncertainties will be dealt with mainly in the following section. The important practical question of how error types as defined by their behavior are to be identified in terms of their known causes will be discussed in section 2.3. In the interest of brevity, the term “experiment” will stand in what follows either for a single measurement; a set of measurements, some of which may be repetitions; or for a whole experiment as usually understood. The term “result” will be used for the value obtained from an experiment in any of these three senses.

The Fundamental Four-Fold Error Classification

When an experiment is repeated many times, four types of behavior are possible in the observed results as shown in figure 1 . . .

1) each result may differ from the true value by the

same amount and with the same sign, i.e. the error is constant,
2) each error may vary randomly realizing a stable random distribution with a non-zero mean,
3) each error may vary randomly realizing a stable distribution with a zero mean, or
4) each error may vary non-randomly (e.g., cyclically or by failing to produce convergent frequencies).

These four classes of error are doubtless capable of further division, but the classification as it stands is obviously unique in any given case and exhaustive since it consists of successive dichotomies or disjunctions of logical complements: constant error or varying error (non-randomly or randomly (non-zero mean or zero mean)). In other words, there are no errors which do not belong to one or another of these four classes and none belonging to more than one. Since the classification is exhaustive, any other classification of error-related concepts, including that in terms of systematic and random types, must embrace all four classes if it is also to be complete.

The Definition of ‘Random’ and ‘Systematic’ Errors

Although the exact nature of the distinction between systematic and random errors is often a matter of confusion, the practical motive behind it is clear enough. It arises from the perception that some errors, the “random” ones, can be treated
statistically and in principle reduced to any desired level *solely on the basis of results*, while others, because of a tendency to act in one particular direction, cannot. The latter group of errors, the “systematic” ones, must therefore be assessed, and perhaps corrected for, independently of results.

But however clear the motivating ideas may appear, there is a widespread and crucial confusion in orthodox error theory about what types of population of results may be said to contain random errors. Must the results be *actually observed* by the experimenter when repeating his experiment before the existence of random errors can be contemplated? Or is it sufficient that the results *could be* observed repeatedly, though the experimenter chooses to conduct a measurement just once? Can errors in the repeatedly observed or single results of others be regarded as random when the results are used to calculate that of one’s own experiment? Could it ever be correct to regard the error in the single result of some “trial” associated with an experiment, but not usually regarded by the conservative as part of it, as random (e.g., a scale error in an instrument “randomly” chosen for use)? These questions will be addressed later, but here definitions of “random” and “systematic” will be formulated which could be applied to any population of results accepted as “statistical.” For simplicity the initial discussion is cast in terms of results obtainable by repeating an experiment.

Clearly a class 1 error could never be evaluated by contemplating a sample of results, however large, since, being the same for each result, it would lead to no differences in successive values from which its magnitude and sign could be inferred. An error of this kind, caused perhaps by a constant unwanted and uncorrected physical effect, is often regarded by the conservative as the standard case of a systematic error. As such, it is contrasted with a class 3 error which can be assessed in detail and reduced to any desired level by taking the average of a sufficiently large sample of results. This is the standard case of a random error.

The relation of class 2 errors to the random versus systematic distinction is less straightforward. The conservative frequently likes to oppose systematic to random errors, yet here is a randomly distributed error which nevertheless introduces on average a non-zero error into results which cannot be reduced indefinitely solely by averaging a large sample. However, while it may not be obvious how to classify class 2 errors themselves, every class 2 error can clearly be said to consist of a class 1 systematic component and a class 3 random one, the former component being identified with its mean or expected value. Indeed, since the evaluation and treatment of uncertainties is always carried out separately for each component, there is no practical necessity to classify class 2 errors themselves. Definitions of “systematic” and “random” might therefore be adopted which result in class 2 errors being one, the other, neither, or both according to taste.

The above view of the mixed composition of class 2 errors need not, of course, imply an assumption that their constant or systematic component corresponds to any single physical cause or group of causes different from those giving rise to the random variation. Although they can be produced by distinct class 1 and class 3 errors, generally both components will have a cause or causes in common and in that sense are part of the same error. For this reason formal definitions of “random” and “systematic” would need to refer both to errors and error components.

Cast in terms of a result $y$ instead of an error $\Delta y = y - y_0$, where $y_0$ is the true result, the definition of systematic errors as class 1 errors or error components is equivalent to that sometimes offered in terms of statistical bias: $E(y) - y_0$.

Class 4 errors are probably far more common than is generally realized. For example, any error that increases uniformly with time, even if “sampled” at random intervals, would be of this kind. In spite of the biasing existent is not usually recognized. Class 4 errors cannot, of course, be counted as random, but it is of little practical importance whether they are held to be systematic or are neither random nor systematic.

In the light of these considerations “systematic” and “random” errors might be defined by the scheme set out in box 3 or by equivalent definitions which would not necessarily be cast in terms of the four-fold error classification. Class 2 errors, the categorization of which was seen to have no practical signification, have been arbitrarily taken to be neither random nor systematic and class 4 errors to be systematic.

The definitions of errors of classes 1 to 4 were physical ones cast in terms of what behavior would be observed if an experiment were repeated many times.

---

3 Such a resolution is always possible for any class 2 error $\Delta x$. Setting $\Delta x = \mu_{x1} + \Delta r$, where $\mu_{x1} = E(\Delta x)$ and the random variable $\Delta r = \Delta x - \mu_{x1}$ one has for its expected value $E(\Delta x) = \mu_{x1} + E(\Delta r)$. Thus $E(\Delta r) = \mu_{x1} - \mu_{x2} = 0$ so that $\Delta x = \mu_{x1} + \Delta r$. $\Delta r$ being a class 3 error as asserted.

4 Systematic error defined in terms of a class 1 error or error component $= \mu_{y1} = E(\Delta y) = E(y - y_0) = E(y) - y_0$ = systematic error defined in terms of bias.
Box 3. A Possible Definition of ‘Random’ and ‘Systematic’ Errors

<table>
<thead>
<tr>
<th>Orthodox Category</th>
<th>Error or Error Component</th>
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<tr>
<td>Systematic</td>
<td>class 1 error</td>
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<tr>
<td></td>
<td>class 1 component</td>
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<tr>
<td></td>
<td>of class 2 error</td>
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<td></td>
<td>class 3 component</td>
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<td>of class 2 error</td>
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<tr>
<td>Neither</td>
<td>class 2 error</td>
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</tbody>
</table>

times according to a clear experimental specification. Thus what class an error belongs to is a completely objective matter when it arises in results of repeatable measurements. Since the definitions of “random” and “systematic” error of box 3 are cast in terms of error classes 1 to 4, they too are objective categories applicable to all such errors.

It should also be noted that the subjunctive or “counterfactual” nature of the definitions (“... would be... if an experiment were...”) enables single-reading errors to be called “random” or “systematic” even though the concepts are defined relative to a large population of errors. This should not be a matter for concern, of course; physical properties are typically “dispositional” in this way. That is, they are manifested only under appropriate conditions, but are held to persist in their absence. This important point will be discussed further in section 2.3.

The Definition of ‘Systematic Uncertainty’

Once “systematic error” is defined, “systematic uncertainty” can be defined in terms of it. There are several ways of doing this of which the simplest is the following:

The “systematic uncertainty” in a given direction in the result of an experiment is the magnitude of the range of its possible values as defined by knowledge of its maximum possible systematic error or error component in that direction.

This concept of systematic uncertainty has been criticized because limits which are literally the maximum possible are often absurdly large and in most practical cases there is an ineliminable element of “subjective” judgment in assessing plausible ones. Indeed, it is at this point that some experimenters abandon orthodoxy and introduce probability concepts to confine the range of the error to lie within conceivable rather than possible limits (cf. the definition of “random uncertainty” below).

But the conservative does not concede that it is appropriate to treat all errors as random errors. He usually prefers to abandon the definition of “systematic uncertainty” in terms of maximum possible error, but maintains that there are systematic errors which are not randomly distributed in his experiment (e.g., errors due to the use of biased theoretical corrections required by its specification). Uncertainty is therefore to be treated in terms of what Eisenhart has called “credible bounds” [11]. These are often said typically to be less than the maximum possible bounds, but if probabilities are employed in judging them they are held not to contribute to the random uncertainty of the final result. The conservative may also wish to maintain that there are some practical cases where admissible probabilistic information is lacking and where credible bounds are best replaced by maximum possible bounds.

The Definition of ‘Random Uncertainty’

The expression “random uncertainty” is conventionally defined in terms of “random error” as follows:

The “random uncertainty” in a given direction in the result of an experiment is the magnitude of the range of its values as defined by a knowledge of its maximum conceivable random error or error component in that direction.

The use of “conceivable” here where “possible” was used in the previous definition, is in recognition of the common necessity of choosing a confidence level of less than 100% probability which for many distributions corresponds to the range ± infinity. The justification of this procedure, apart from necessity, is that everyone is prepared to discount possible exceptions at some low level of probability.

2.2 The Orthodox View of the Combination Uncertainties

The law of error propagation states how various errors in an experiment combine to produce the error in its final result. Unfortunately the combining errors are not usually known, else they could be corrected for at source. What are usually known instead are their estimated maximum possi-
ble values, credible bounds, variances, or other quantities related to their respective uncertainties. How does the conservative use this information to estimate the uncertainty of his final result?

**Orthodox ‘Combination’ of Random Uncertainties**

The estimation of the random uncertainty resulting from the combined effect of two independent random errors is unproblematic in principle. The distributions of the errors convolute and their standard deviations combine in quadrature (i.e., their variances add) to produce those of the resultant error. Resultant random uncertainty is to be estimated from the resultant distribution relative to some choice of a confidence level close to one. It should be noted that in general random uncertainties, as opposed to standard deviations, do not combine in quadrature to yield a correct resultant random uncertainty. This may easily be demonstrated by consideration of the combination of two similar, but independent, uniformly distributed random errors, for example, which yields a resultant with a triangular distribution. The only exception to this rule arises from the combination of normally distributed errors which interact to form another normally distributed error; here uncertainties do combine in quadrature. But in general, unlike the expression “combination of errors,” the phrase “combination of uncertainties” can be misleading.

**Orthodox Combination of Systematic Uncertainties**

Wavering conservatives sometimes entertain the notion that systematic uncertainties can be combined in quadrature to obtain a resultant systematic uncertainty [10,11]. This view may arise from feelings that it would be improbable that many systematic errors would all pull in the same direction or, more specifically, that \( p(+) = p(-) = 0.5 \) (Bayes’ postulate applied to signs); that in ignorance of their values they are uniformly distributed between bounds (Bayes’ postulate applied to errors); and that credible bounds must be something like standard deviations because they are assessed from probabilistic considerations. However, combination in quadrature of systematic uncertainties is fundamentally inconsistent with the orthodox theory one of the first principles of which is that there exist constant errors and error components. That constant error-like quantities combine in a linear way is accepted by everyone. There is no dispute that when the distributions of combining random variables are convoluted to produce a resultant distribution, the mean of this distribution is simply the arithmetical sum of those of the combining variables. This is true in error theory as in other fields of statistics and applies in particular to class 2 errors. To the consistent conservative the rationale for this is that the means are to be regarded not as random variables but as constants of the experiment of unknown sign and magnitude (or “constants of nature” in general statistical parlance). This is because they are parameters of particular error populations explicitly or implicitly identified by any complete experimental specification. As such, the means cannot be said in any physical sense to be drawn from a population and are undistributed except, perhaps, in the form of a delta function at some unknown location between credible bounds. Since no probabilities can be assigned to their various possible values the upper limit to be placed on the sum of the means can only be obtained from the sum of their individual upper limits, however defined. This becomes a simple point of logic where upper limits are defined to be maximum possible values. But even when credible bounds are employed, they are still intended to confine the conceivable values of unknown, undistributed constants which are agreed to combine in a linear way and could all pull in the same direction. Thus the consistent conservative permits himself no recourse to statistical procedures in such cases and must recommend that systematic uncertainties be combined in a linear way. Even if it were thought that systematic quantities were randomly distributed, uncertainties as opposed to systematic “standard deviations” would not be the appropriate quantities to combine in quadrature as argued above (cf. box 1, recommendation 3).

**Orthodox Combination of Random With Systematic Uncertainties**

How are uncertainties corresponding to “mixed” (class 2) errors to be evaluated on the orthodox view? Little guidance on this important matter is to be found in conservative literature, but a procedure is easily devised. In the case of a class 3 error, uncertainties \( u_+ \) and \( u_- \) are obtained from a confidence level \( p_h \) applied to a single class 3 distribution. In calculating \( u_+ \) and \( u_- \) for a class 2 error, the consistent conservative must consider not one distribution, but two different worst-case distributions as shown in figure 2. These arise in the following way:

- the form of the distribution of the purely random component of the error is observed or inferred as it might be for the case of a class 3 error, but its mean \( \mu_{\Delta e} \) is unknown,
the maximum positive limit on its mean, $\mu_{\Delta_{\text{max}}}$, is obtained by summing its component limits in the way argued for above,

- similarly, a minimum negative limit on its mean, $-\mu_{\Delta_{\text{min}}}$, is calculated,

- one worst-case distribution is obtained by setting $\mu_{\Delta} = +\mu_{\Delta_{\text{max}}}$ simply because this represents one of the two worst conceivable situations.

- similarly, the other worst-case distribution is obtained by setting $\mu_{\Delta} = -\mu_{\Delta_{\text{min}}}$.

The probable presence of large positive errors implies the necessity of a large negative uncertainty. Thus in order to obtain a value for $u_-$, the conservative now "slides" a vertical boundary out along the positive error axis until a small fraction $(1-p_L)/2$ of error values is enclosed beneath the curve to the right of the line. A similar process conducted in the opposite direction will yield $u_+$. (The convention of choosing a value of $p_L$ to exclude a fraction $(1-p_L)/2$ rather than $(1-p_L)$ ensures continuity with the usual convention for class 3 errors as $\mu_{\Delta_{\text{max}}}$ and $\mu_{\Delta_{\text{min}}}$ both approach zero.)

This procedure covers cases where positive and negative systematic uncertainties or the random components of errors or both are disposed asymmetrically. But it does not, of course, allow probabilities to be associated with $u_+$ and $u_-$ as with the uncertainties corresponding to class 3 errors because none was associated with $\mu_{\Delta_{\text{max}}}$ and $\mu_{\Delta_{\text{min}}}$. It might be said that at least an estimated fraction $p_L$ of the results of a repeated experiment would lie between $y - u_-$ and $y + u_+$, but not that an estimated fraction $1-p_L$ would lie outside this range. For this reason no probabilities can be associated with the compatibility of two experimental results $y_a$ and $y_b$ ($y_a > y_b$) where either or both have mixed errors. They agree if $u_{+_a} + u_{-_b} > y_b - y_a$. If $u_{+_a} + u_{-_b} < y_b - y_a$, they disagree. On the orthodox view, there is no more to be said.

No analogous analysis of error-related quantities other than uncertainty is offered here. The estimation of expected values of errors, of their expected absolute values or of rms values requires that $\mu_{\Delta}$ or $E(\mu_{\Delta})$ is known. The conservative believes that they are equal because the former is a constant and not a distributed random variable. But since it is an unknown constant he is bound to regard the derivation of expressions for expectations to be of no practical use. It will be seen later that supporters of the randomic theory take a different view and that $E(\mu_{\Delta})$ is assumed to be calculable even when $\mu_{\Delta}$ is not known with certainty.

2.3 Error Types and Their Identification on the Orthodox View

It has already been noted that there is often confusion about what populations can legitimately be said to contain random errors for the purpose of estimating uncertainties in experimental results. Since the "combination" of uncertainties depends on the identification of the corresponding error types, this is a matter of some practical importance and the confusion needs to be resolved.

At the beginning of section 2.1, it was pointed out that the distinction between systematic and random errors was sometimes based upon error causes [approach 2], rather than upon the behavior of errors as experiments were repeated [approach 1]). It will be clear that equivalent definitions of "systematic" and "random" could be cast in terms of causes, provided allowance was made for any non-linear dependence upon them of the resulting errors.

While the above possibility is widely intuited, it has never been developed to the author's knowledge. It nevertheless seems tacitly to underpin a different and much less satisfactory type of exercise intended to define systematic errors in terms of their causes. Here systematic errors in results are defined by an enumeration of systematic causes.
Some typical cases are shown in box 4. But such enumerations amount only to definition by example and so cannot be fundamental. Without a prior criterion stating how causes are to be related to one category or the other, the classification would not be possible. In the absence of a statement of the criterion the procedure remains obscure and, equally important, there is no way of telling if it is complete. It seems clear, however, that in each case the vague underlying notion is that such errors are class 1 or constant errors. Unfortunately the errors listed in box 4 do not always behave as class 1 errors when the relevant trial is repeated, as will be argued below. The enumeration is based on simplistic rules-of-thumb which are no substitute for a physical analysis of the way their causes operate. In what follows, errors defined in this way will be referred to as “so-called” systematic errors to distinguish them from those defined in terms of their behavior (cf. box 3).

Also mentioned at the beginning of section 2.1 were definitions of “systematic” and “random” cast in terms of how errors or uncertainties are actually estimated or treated in a given case, rather than in terms of what is possible or proper in view of their nature [approach 3]. When such definitions are offered it is sometimes unclear whether it is intended that the method of evaluation or treatment determines what category errors fall under or vice versa. Here it will be assumed in the interest of objectivity that it is the nature of the error which determines the correct method of evaluating its corresponding uncertainty, so that no definition purporting to be fundamental need ever mention the actual methods of evaluation employed in given cases. The opposite view is again related to the aforementioned confusion about which populations of results can be said to contain random errors. The errors of box 4 frequently arise from random processes and so arguably contain a random component. But such components will have a constant effect when combining with errors in the results of other measurements, no matter how often, the latter are repeated. From this it is sometimes concluded that the errors of box 4 cannot be held to contain a random component for the purpose of calculating an uncertainty in one’s own result. Thus one author, having given examples of systematic errors, writes, “There is no strict definition of systematic errors, since what is systematic for one experiment may not be for another” [12]. Another states, “One has to remember that some errors are random for one person and systematic for another” [13]. This outlook may have led to the mistaken view that the central orthodox distinction is mutable and that the labeling of errors as “random” or “systematic” is somehow conventional. Credence has thereby been lent to the notion that what is actually done is as important as why it is done. Fortunately the confusion can be removed by resolving certain more fundamental ones about probabilities and it can be stated definitively what

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**Box 4. An Orthodox Definition of ‘Systematic Error’**

**By Enumeration of Causes**

*(‘So-called’ Systematic Errors)*

“Systematic errors” are those owing to:

- Single readings
  - rounded
  - interpolated

- Instrument errors
  - calibration errors
  - other scale errors
  - errors due to “subclinical” malfunction
  - errors due to bad practice

- Residual correction errors arising from inexactness in correcting for known systematic effects

- External errors arising from results taken from other experiments
populations can correctly be said to contain random errors. It will then be clear that the distinction between random and systematic errors is an objective one and that the nature of any given error is fully determined once a complete experimental specification has been formulated.

The confusion is well illustrated by the much-discussed problem case of external errors. Two possibilities exist for their treatment. The error in an external quantity might be taken to be entirely systematic, even where the worker producing the result can be said to have correctly assessed it as being entirely random or part random and part systematic. The alternative is to take over the error assessment, assumed correct, of the original worker in deriving the uncertainty of one’s own result. The justification of the former view is that no matter how often the main experiment is repeated, errors in the external result will always affect the answer in the same direction and to the same degree; i.e., it is a class 1 error. Thus one experimenter’s random error is another’s systematic error. But the opposing view notes that if the external measurement had been conducted by the “borrower,” it would be regarded as an ancillary measurement in his own experiment and no question would arise of changing any random component in its uncertainty to a systematic component. Who did what is held to be an unphysical consideration which could not change the nature of an error and so the original worker’s analysis is to be retained.

The position will be adopted here that the latter argument is the correct one. While the random component of an external error certainly will affect the result of the experiment in hand with a definite sign and magnitude (what other way is there?), this is true only in the sense that it is true for its own internal random error. The best estimate of the internal error introduced by an external random error component is zero with an uncertainty based on the latter’s distribution (cf. Campion et al., [14]).

To see this more clearly some may find it helpful to consider a simple gaming analogy of a class 3 error. Suppose a die, possibly loaded, is thrown repeatedly to estimate the unknown expected value \( \mu_r = E(n) \) of the outcome \( n \) (1 to 6). Here \( \mu_r \) is analogous to a true value to be determined by measurements, \( n \) to the observed (digital) results, and \( n - \mu_r \) to a class 3 error. After a single throw the “error” \( n - \mu_r \) is, like a measurement error in a single reading, physically determined, but unknown. Nevertheless, everyone would accept that some unknown, but objective, probability was in principle to be associated with it and that this would be the same whether one threw the die oneself or someone else threw it. For example, in the case of a fair die \( p(n - \mu_r) = 1/6 \) for any \( n \) where \( \mu_r = 21/6 \).

Suppose further that it is desired to assess the uncertainty in an estimate \( n \) of \( \mu_r \), obtained as the mean of 100 outcomes, one of which was provided by an outsider. Would it be correct to calculate random uncertainties \( \pm u \) in \( 2n/100 \) at, say, the 95% level of confidence for 99 throws and then to augment these by maximum error limits, \( u_1 = (\bar{n} - 1)/100 \) and \( u = (6 - \bar{n})/100 \), corresponding to the single “external” result? Of course no one would proceed in such a way. The uncertainties would be calculated at the 95% level of confidence for the full 100 throws. Thus “external” random quantities are to be treated no differently from “internal” ones as asserted.

This justification for the ruling that external random errors are not to be distinguished from internal ones is easily generalized and so provides a basis for the resolution of the question of which populations of results can legitimately be said to contain random errors. It means that in principle any error determined by a random process, whether under the management of the experimenter or not, is to be treated as a random or part-random error even if it occurs in a single result. This accords with universally accepted statistical principles as applied in the above gaming example and licenses experimenters to treat many so-called systematic errors, or components of them, as random. Thus random errors in the result of an experiment can arise from external results, from calibrations and, if an experimenter’s instrument can realistically be said to be sampled at random from some population, from instrumental imperfections which do not change in the course of his measurements. Similarly, if a conservative were, unusually, in a position to assess “credible bounds” for a so-called systematic error in his experiment using knowledge of the form of its random component, these bounds too should be treated as partly or wholly random uncertainties. As a result of these reforms of orthodox practice, reductions can be made in many overall experimental uncertainties conservatively estimated on the incorrect assumption that some of their components were purely systematic. This is so because combination in quadrature is permitted for the standard deviations of the newly identified random error distributions. However, as will become clear in section 3, the fact that all assessable external random error components are to be treated as such does not imply that all external error components are random.

From these considerations it is clear that the identification of an error as random or systematic
or a mixture of both should be based on an analysis of the way its causes would operate upon repetition of the experiment or some associated trial. In particular it is necessary to identify all random mechanisms which can affect it even though they are normally regarded as being outside the experiment. The correct identification of error types will be ensured if attention is directed to the \textit{whole} experiment including those parts conducted by others and the random trials performed, perhaps unwittingly, by oneself (for example, the choice of an instrument). Each repeatable operation in the whole experiment, whether actually repeated or executed just once, should have exactly the same status as one’s own repeated measurements. This broad and rational outlook may be contrasted with the uncritical use of rules of thumb such as those illustrated in box 4.

Six common related failings of conservative argument and practice have been encountered in this section. To summarize, they are . . .
- vagueness about the meaning and objectivity of the basic distinction between random and systematic quantities,
- a confusion about scope: which populations can be said to contain random errors?
- vagueness about the correct method of combining systematic uncertainties.
- vagueness about the correct method of calculating uncertainties corresponding to mixed (class 2) errors.
- the misidentification of error types by the naive use of rules of thumb, and
- failure to notice the widespread existence of random errors.

The realization that the role of random errors in experiments is much wider than orthodox assumptions sometimes allow has doubtless been a stimulus to the alternative view offered by the randomistic theory. And the fact that conservatives appear to have forgotten the reasons for orthodox practice has made the task of the randomistic theory’s proponents an easier one.

3. The Randomistic Theory of Errors

To those nurtured on the orthodox view, the randomistic theory of errors seems initially to be very radical. As the first main tenet of the theory, the distinction between random and systematic errors is held either to be a merely conventional distinction without an objective difference or to be a real, but irrelevant, distinction for the purposes of determining uncertainties in practical cases. However, which of these views is held by any given proponent of the randomistic theory (or “randomistic,” for ease of reference) may not always be clear. The second main tenet of the theory is that all uncertainties are to be calculated by statistical techniques, for example by combining “standard deviations” in quadrature irrespective of how a conservative error theorist would classify their corresponding errors.

There can only be three main types of justification of the new theory. The first, presented in section 3.1, takes as its starting point the generally agreed law of error propagation and uses it to attempt to show that random and systematic standard deviations, so-called, are logically required to be combined in quadrature [15–17]. That being the case, the distinction, whether originally valid or not, is shown to be irrelevant for arriving at an overall assessment of uncertainty. On this approach, the randomistic’s second tenet would appear to be the more fundamental.

The second and third justifications of randomistic procedures depend not on the law of error propagation, but on the assumption or perception (depending on one’s position) that all errors of interest classified by the conservative as systematic can be associated with random variables having a parent population over which a probability distribution can be defined. The conservative, on this view, has simply failed to notice something useful; namely that all errors are random and can, even according to his own beliefs, be treated statistically. It is thus implied that the central conservative distinction corresponds to no real difference and the first randomistic tenet plays the more fundamental role by providing a justification for the second. This type of argument can be fundamentally different when cast in frequency-based terms (Justification 2 presented in section 3.2) from that cast in subjectivist terms (Justification 3 presented in section 3.3). A number of authors have proposed procedures for uncertainty estimation based on the assumption that all errors can be represented by random variables, but it is generally unclear whether Justification 2 or 3 is intended [18–21].

3.1 Justification 1: Randomistic Theory via the Law of Error Propagation

The law of error propagation, which is quite uncontroversial, states that the error $\Delta y$ in the result $y$ of an experiment is given by

$$\Delta y = \Sigma \left( \frac{\partial y}{\partial x_j} \right) \Delta x_j$$
where the \( \Delta x_i \) are the errors in the various individual or repeated measured values of \( x_i \) of the experiment. To illustrate why it is thought that both random and systematic "standard deviations" are to be combined in quadrature the simple case will be considered where the required result of an experiment is the mean of \( n \) similar results \( x_i: \)
\[ y = \frac{\sum x_i}{n} \]
Let the \( x_i \) suffer systematic errors \(+a\) and \(+b\) with a random error \( R_i \) so that
\[ \Delta x_i = a + (b - 1)x_i + R_i \]
Approximate corrections \(-a - \Delta a\) and \( -(b - \Delta b)\) would generally be made to the observed \( x_i \) whereupon
\[ \Delta x_i = \Delta a + \Delta bx_i + R_i \]
It is easily shown that, provided the expectation \( E(\Delta a \Delta bx_i) = 0 \), the law of error propagation implies:
\[ E(\Delta y^2) = \Delta a^2 + \Delta b^2 + \sigma_x^2/n \]
where \( \sigma_x^2 = E(R_i^2) \) i.e., "standard deviations" of residual correction errors and random errors combine in quadrature. It is assumed that in any well-designed experiment significant systematic errors will always be corrected for and that this therefore provides a general rationale for practical randommatic procedures of the kind which those recommended in box 1 appear to be.

**Problems with Justification 1**

The conservative, is unlikely to find Justification 1 convincing for two reasons. Firstly he would not accept that systematic errors were always corrected for in well-designed experiments. There are many cases where a systematic error is tolerably small and where a reliable correction is difficult to estimate. Here the experimenter will often prefer to leave it uncorrected and to estimate the uncertainty in terms of bounds. For the argument to work in such a case it would be necessary to assume not that \( E(\Delta a \Delta bx_i) = 0 \), but that \( E(a(b - 1)x_i) = 0 \), which is only true in general if the errors \(+a\) and \(+b - 1\) are uncorrelated class 3 ones like the \( R_i \). But this is exactly what the conservative denies; it will be recalled that the existence of class 1 errors is the first principle of his theory. If anyone repeating the experiment according to the same experimental specification could be expected to encounter the same constant values of \( a \) and \( b \), then it would be the case that \( E(a(b - 1)x_i) = a(b - 1)x_i \). More generally, if the errors \(+a\) and \(+b\) were always drawn from the same two respective populations with unknown non-zero means \( \mu_a \) and \( \mu_b \), then \( E[a(b - 1)x_i] = \mu_a \mu_b - 1 \neq 0 \).

The conservative's second objection would be that, even where corrections are made for systematic errors, different residual correction errors are not generally statistically independent class 3 errors either. For example if \( a \) and \( b \) arose from two corrections made for systematic effects on the basis of simplified theoretical models which all experimenters following the specification would be expected to use, then \( \Delta a \) and \( \Delta b \) could be constant class 1 errors in which case \( E(\Delta a \Delta bx_i) = \Delta a \Delta b \).
From this it follows that
\[ E(\Delta y^2) = (\Delta a + \Delta bx_i)^2 + \sigma_x^2/n \]
which is the usual conservative formula with systematic errors combining together in a linear way. The enlightened conservative believes that typically residual correction errors, like most so-called systematic errors, would be of class 2 so that \( E(\Delta a \Delta bx_i) = \mu_a \mu_b \neq 0 \) as before. It is therefore the case that Justification 1, though perfectly correct given certain randommatic presuppositions, cannot be used to establish those presuppositions on pain of circularity. The conservative will see the argument as begging certain key questions as controversial as Tenet 2 itself. The same applies to any justification employing a statistical proof that standard deviations combine in quadrature and which implicitly assumes that all errors are random variables of zero mean (e.g., [22]). It will become clear that Justification 1 is implicitly dependent on the reliability of Justification 2 or 3.

3.2 Justification 2: Randommatic Theory via Frequency-Based Statistical Distributions

This justification depends upon the assumption that every systematic error belongs to a well-defined stable population which can be generated by repeated measurements or by some other repeatable trial associated with the experiment. For example a barometer zero error might be said to be long to and be sampled from the population of zero errors realizable by constructing an infinite population of barometers to the same engineering specification and perhaps subjecting them to the same calibration procedure. The error would thus be fixed for any given experimenter executing the experimental procedure, but would be a random variable analogous to a single reading (cf. the discussion of conservative attitudes to such quantities in section 2.3). From this it might be argued that all errors were random errors.

**Problems with Justification 2**

The results of measurements repeated according to a clear experimental specification, and the corresponding errors, belong to well-identified populations; those defined in advance by the specification.
But what population do those systematic errors "outside" the experiment belong to? It might be argued that if a systematic error could be assigned to more than one population equally naturally with no means of identifying the "right" one, different but equally correct standard deviations and uncertainties could be derived. They could not therefore be objective quantities (cf. Ayer [23]). For example, does a barometer zero-error belong to 1) the population of zero-errors realized by repeated constructions to the same specification or to 2) the different population of zero-errors to be found in barometers available for use in (say) British laboratories? Since randomistic do not identify their populations, but simply invoke distributions or even just standard deviations, their calculated uncertainties cannot in practice be objective frequency-based ones.

However, though this may be true of informal practice, there is no deep problem of principle here for the randomistic theory. So-called systematic errors really can belong to several natural populations from which they are simultaneously sampled. The experimenter may use his approximate knowledge of these to choose or define the population characterized by the smallest errors as the basis of his calculation of uncertainties, provided that the population involved really would be randomly sampled by repetition of the error selection procedure actually employed in his experiment (e.g., through the purchase of a barometer by his organization). If, for example, he judges that zero errors of British barometers in general would only very rarely exceed ±30 Pa, but that his particular design would limit this to ±10 Pa, then it is legitimate to use the latter information ignoring the former. Different experimenters may draw their barometers (and their zero errors) from the same or different populations. But if these are properly identified and their corresponding distributions or bounds plausibly assessed, uncertainties will be correctly estimated in each case. Because the population sampled is a determinant of the experimental result and its error, it will be supposed in all that follows that it must be explicitly or implicitly identified in a complete experimental specification and is not to be regarded as a matter "outside" the experiment (cf. section 2.3).

But there is a more serious objection to Justification 2 than the charge that randomistic populations of systematic errors are not uniquely identifiable. This states that their distributions are not generally of class 3 having zero means. As noted in the previous section, unknown non-zero means for residual correction errors are only to be expected. And this is true in general of the frequency-based distributions characterizing genuinely physical error populations. For example, there is no reason to suppose that the populations 1) or 2) above have zero means. Indeed there exist many errors which can only have one particular sign and for which corrections are not made. Thus if randomistic procedures are to be justified, it cannot be in terms of frequency-based distributions.

To avoid this conclusion it would have to be demonstrated that the means of class 2 systematic error populations (so-called) were themselves class 3 random variables appearing with different frequencies in some physical population sampled by the experiment. Then it would arguably be appropriate to convolute the distribution of the mean with that representing the purely random variation of the so-called systematic error to yield a frequency-based class 3 resultant distribution as required by the randomistic theory. But, the view that means (systematic errors proper) are distributed in the sense of appearing with different frequencies in some physical population would betray a misconceived identification of the relevant experiment and population. It has been noted that complete experimental specifications must identify, albeit implicitly, a particular so-called systematic error population as an essential feature of the experiment. While the corresponding distribution and mean are not known, they are determined through the definition of the experiment and not through some external random trial. Different workers independently following exactly the same experimental specification will therefore sample the same error population, producing results with a random variation, but all sharing the same bias from the true value. Thus the mean of the error is clearly sampled from a population of just one value. Since experimenters are interested in estimating the maximum possible or conceivable error in a particular specified experiment, the conservative is right to regard the mean as an undistributed quantity or as being "distributed" as a delta function at some unknown location. Of course, if the error population were investigated statistically, an estimate for its mean could be obtained and the error in the estimate characterized by a random distribution. The mean would be corrected for and the error in the mean would be treatable as random. However, the mean would then, by definition, not be a systematic error, but a measured quantity.

The randomistic, if he seriously invokes a frequency-based distribution for the uninvestigated mean, is implying that it is in a literal sense singly sampled from some wider population once-and-for-
all on behalf of all the independent experimental repetitions which could ever be conducted. Perhaps the population envisaged would be that of systematic errors, positive and negative, encountered in experiments in general, with the credible or maximum bounds re-scaled and re-dimensional in each case to match those of the experiment in hand. Apart from the problematic question of whether this "super-population" of means itself has a zero mean, there would be no objection to randomic procedures if this experiment were like that for which an uncertainty is required. But it is quite different from the conception of the experiment normally held. If this experiment were repeated, there would be a grand prefatory sampling of the error mean on each occasion followed by repetitions of the experiment as normally conceived. The results and the errors would then be different from those of the experiment for which an uncertainty is sought.

The constancy of the unknown mean which the conservative takes so seriously is therefore of quite a different nature from that of the determined outcome of a prefatory single sampling. It is built into the common concept of an experiment as a definite specified trial. As such there is no frequency-based rationale for treating uninvestigated systematic error means statistically and any justification of randomic principles must hang on subjectivist arguments.

3.3 Justification 3: Randomic Theory via Subjectivist Statistical Distributions

Modern subjectivist statisticians frequently identify probabilities with rational "degrees of belief." Their general method is 1) to assign prior probabilities \( p(x_i) \) to the possible results \( x_i \), of some trial reflecting their beliefs prior to making observations, and 2) to modify these in the light of evidence \( E \) (observed frequencies) using Bayes' theorem to yield posterior probabilities:

\[
p(x_i | E) = \frac{p(E | x_i) p(x_i)}{\Sigma p(E | x_i) p(x_i)}
\]

In this way posterior values converge with those evaluated conventionally and they "realize" the same distributions as others. These will of course be different in general from their prior distributions.

In many subjectivist treatments of statistics, the psychological concept of a "degree of belief" is defined in terms of the betting odds which a subject would just be prepared to accept on such-and-such being the case. This notion, together with certain weak rationality constraints, for example betting in such a way as to avoid becoming the victim of a Dutch book, are held to be sufficient for deriving the axioms of probability theory.\(^5\)

A familiar example of intuitive subjectivist practice is afforded by the situation where an experimenter has no information on whether a so-called systematic error is positive or negative and knows nothing about its magnitude except that it cannot exceed \( |a| \). Having no reason to believe any value in the range \( \pm a \) more or less probable than another, he invokes a uniform Laplacian distribution of magnitude \( 1/2a \) between \( \pm a \). Such a distribution is of course of class 3.

It has already been noted that it is essential to the randomic theory that any distribution used to calculate uncertainties is of class 3. This is because a standard deviation, the only recognized "measure" of uncertainty, is defined relative to its distribution mean and so cannot reflect uncertainty arising from an unknown and unobservable non-zero distribution mean. (Covariances too, like those invoked in box 1, are defined relative to means and so can only allow for bias arising from correlation between purely random components of errors.) Unlike frequency-based distributions for systematic errors, subjectivist distributions are generally of class 3 because the sign of a systematic error is typically unknown. Where the distribution is not of class 3 corrections are sometimes applied to make it so. That subjectivist distributions are of class 3 is the great strength of Justification 3 compared to Justification 2.

However, because class 3 prior distributions which are not frequency-based are by definition undetermined by evidence, they are not objective. Different subjectivists will invoke different prior distributions and so calculate inconsistent standard deviations and uncertainties. More importantly, they will disagree in general from those which could be realized by repetition of the relevant trial. If they were to agree, it would be because there was sufficient knowledge to calculate approximate

\(^5\) The most detailed foundational development of subjectivist theory in terms of rational betting and Bayesian conditionalization has been undertaken by de Finetti [24,25]. Useful reviews of his work may be found in Gillies [26,27]. Clear statements of subjectivist ideas have also been presented by Savage [28,29] who in the latter gives a schematic subjectivist account of a physical measurement (the weighing of a potato). Two wide-ranging collections of subjectivist and Bayesian papers are "Studies in Subjective Probability," edited by Kyburg and Smokler [30], and "Bayesian Analysis in Econometrics and Statistics," edited by Zellner [31]. A modern mathematical text extending the tradition in a philosophically conscious way is "Statistical Decision Theory" by Berger [32]. A well-known critique of subjectivist methodology was presented by Fisher in "Statistical Methods and Scientific Inference."[1]
frequencies in advance. But then frequency-based distributions would have been invoked which are not generally of class 3 (cf. the preceding section). Randomisticists sometimes depend on class 3 subjectivist distributions to justify their recommended procedures for calculating uncertainties, but then make the incorrect assumption that their uncertainties are objective as they would be had their invoked distributions been frequency-based.

The lack of objectivity of prior distributions appears to some to be a fatal flaw in subjectivist statistics. In contrast, subjectivists see it as no great problem. They accept nowadays that such prior distributions are often non-objective best guesses or unbiased starting points for a Bayesian inference and are prepared to engage in mathematical analyses of “robustness” with respect to their uncertain features (roughly, how insensitive the posterior distribution is to any lack of realism in them) [e.g., 33]. Objectivity is achieved through evidence and the process of Bayesian conditionalization. Unfortunately systematic error distributions are by their nature never investigated statistically and conditionalized. In this respect error theory differs crucially from other fields of statistical practice where Bayesian methods are employed. Thus even subjectivists would regard subjectivist prior error distributions and a randomistic theory based on them as non-objective.

With the failure of this justification, it is seen that in spite of its attractive features the randomistic theory lacks an objective foundation. Moreover, if uncertainties are defined to be maximum possible or conceivable errors in the results of particular specified experiments, the lack of objectivity can be expected to result in underestimated uncertainties on occasions. For example, two equal systematic uncertainties $\pm a$ would combine to yield a resultant uncertainty of $\pm 2a$. By treating the corresponding errors as being normally distributed, say, on the grounds that smaller errors are generally to be expected more often than larger ones, and associating the credible bounds $\pm a$ with some confidence level close to one, the randomisticist will calculate an uncertainty corresponding to the resultant error of $\pm 1.41a$ at the same level of confidence. Under unfavorable circumstances both combining errors could be close to the same bound so that their resultant would virtually always lie outside the randomistic uncertainties. Although some experimenters have a compelling intuition that such unfavorable occurrences are “improbable,” especially where larger numbers of systematic errors combine, it is impossible to provide a physical rationale for this if systematic errors cannot be random variables in any objective sense. After all, none betting on the joint outcome of several particular dice known to have various undetermined biases would assume that the biases had zero expectations unless, unlike systematic errors, they had been randomly selected from a population in which this was true. The psychological origin of the intuition is no doubt the desire to believe that probabilities will always provide a basis for rational inference and action in the face of uncertainty (cf. Fisher [35]). But if the preceding arguments are correct, this would appear not to be so.

4. Conclusions and Recommendations

It has been argued that the distinction between random and systematic errors is, when properly formulated, a clear and objective one applicable to all error populations. Moreover, which category an error falls into should determine whether it is treated statistically or not. Thus there is no room for a different fundamental distinction between error types A and B based on the method of treatment employed in given cases (cf. box 1). Frequently, conservatives have automatically taken so-called systematic errors like those of box 4 to be entirely systematic when they have in fact contained an assessable random component. Conversely, randomisticists have implicitly assumed that all so-called systematic errors are class 3 random errors having zero means. Thus both typical conservative and randomistic practices are based on unrealistic principles.

Given that many so-called systematic errors do contain both a random and systematic component, how are their corresponding uncertainties to be assessed? The formal answer to this question has already been given in section 2.2 where a procedure was recommended for estimating the uncertainty corresponding to a class 2 error (cf. fig. 2). However, this procedure is very often difficult to apply because insufficient information is available to characterize separately the class 1 and class 3 components of class 2 errors.

In dealing with such cases, experimenters of all persuasions often feel able to judge maximum possible or credible bounds beyond which the unknown distribution is certain to cover zero or a negligible probability. The bounds will often be

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Footnote: Early subjectivists sometimes regarded Bayes' postulate or some variant thereof as an unchallengeable axiom; this view led to well-known logical difficulties and is not generally held by modern subjectivists [34].
symmetrical about zero, but it should not be supposed that they correspond to equal confidence intervals of the real distribution or license the experimenter to invoke a symmetrical or other class 3 distribution spanning them. As they are estimated from the worst possible or conceivable combination of physical effects it may well be that the incidental physical influences on the parent error population cause one or both tails of the distribution to become negligible well within their respective bounds (cf. the three curves shown in fig. 2). Thus many distributions are consistent with the choice of bounds and the mean of the real distribution could in principle lie anywhere between them.

Typically the experimenter will be unable to partition his uncertainty as defined by the bounds exactly into random and systematic components. Guided by the definition of uncertainty as maximum possible or conceivable error, the rigorous worker will adopt as the basis of further calculations a model derived from the maximum apportionment of uncertainty to the systematic category judged possible or conceivable. This is because resultant uncertainties calculated on the basis of an overestimated random component would be too small as random components combine in quadrature rather than additively. His judgment of the maximum apportionment of uncertainty to the systematic category will require him to assess the maximum range in which the mean of the actual distribution could lie. Thus, just as credible bounds were initially placed on the so-called systematic error distribution itself, so narrower credible bounds are placed on its mean, the systematic error as properly defined. Like the outer bounds, the inner bounds will not correspond to confidence limits and do not confine the mean in that sense; there is no pre-existing statistical sample to enable an estimate of the mean and the standard deviation of the estimate to be made. (If there were the mean would be like a measured quantity and it would be proper to correct for it and treat the remaining component as a class 3 random error). However, much vaguer information, perhaps that in the given experimental context smaller errors are more common than larger ones, can sometimes justify restricting the range of possible values of the mean. Where the information required for this is lacking, the inner credible bounds will become coincident with the outer which then become the systematic uncertainties they have so often been taken to be.

It may at first sight be thought that making such judgments is hopelessly arbitrary and the problems have to be acknowledged. But experimenters usually design their experiments so that the difficult uncertainties to evaluate are the least significant. Then some inaccuracy in judgments is tolerable. The difficulties are in any case largely common to all theories of error: judgments of maximum limits or credible bounds for the conservative and of systematic standard deviations for the randomistic are often arbitrary in problem cases. However, their simple rules of procedure only disguise the difficulties without removing them. The approach recommended above brings them into the light and, while it calls for an additional judgment apportioning uncertainty between random and systematic categories, this is not markedly more difficult than those already required. More fundamentally, if the approach is realistic, as has been argued, it should be physically correct.

With these points in mind the following procedures are recommended for the estimation of experimental uncertainty.

**Recommendations for the Evaluation of Experimental Uncertainties**

1. The whole experiment should be defined (cf. section 2.3). All measurements, corrections, calibrations, external results, and single random samplings contributing to the final result of the experiment should be listed. All significant sources of error in the experimenter's own part of the whole experiment should be identified. The nature and magnitude of uncertainties in all other results should be ascertained.

2. Choose a confidence level (e.g., 95 or 99% probability) beyond which possibilities are regarded as being inconceivable. This level should be clearly stated.

3. Decide to which class, 1 to 4, each error belongs. This decision should be made irrespective of whether the measurement or trial was actually repeated or not; the definition of these classes is in terms of what would be observed on repetition (cf. section 2.1). Where measurements have not been repeated, it should be possible to identify the class of any error from the specification of the measurement concerned giving the nominal conditions and procedures required for its execution and their permitted variations. In the case of single trials associated with an experiment (e.g., the selection of an incompletely characterized instrument or material) relevant error populations should be identified and one chosen as a basis for uncertainty estimation which minimizes the uncertainty (cf. section 3.2).

4. If some subsidiary result of the experiment is observed to be subject to a significant class 4 error (so introducing a class 4 error into other
results which it is used to calculate), attempt to identify the weak aspect of the control of the experiment which allowed it to occur. This may be done by experimental tests or by analysis of the experimental specification or both. When identified, repeat the experiment with better control if practicable. Alternatively, estimate the maximum range of values which the uncontrolled causative condition or conditions could possibly or conceivably take, and use these to compute maximum possible or credible errors in the quantities concerned. Treat these as systematic uncertainties according to the procedure of paragraph 5. If the source of the class 4 error cannot be identified, then of course no final uncertainty may be calculated.

5 Estimate the maximum possible or credible absolute values in each direction of the class, 1 errors and of the constant components of the class 2 errors. Again, this may be done by reference to presumed measurement specifications or identified pre-existing error populations. Multiply each uncertainty by the coefficient \( \frac{\partial y}{\partial x} \), in the law of error propagation to obtain corresponding uncertainty components in the final result of the experiment. Add these together to obtain an overall systematic uncertainty in the final result.

6 Identify those class 2 and 3 sources of random error which contribute directly to the final result. Multiply the observed or estimated standard deviation of each by the coefficient \( \frac{\partial y}{\partial x} \) to obtain corresponding components for the final result. Combine these in quadrature to yield a standard deviation for its random component of error.

7 Having observed or inferred the form of the random component of error in the final result of the experiment, use the systematic uncertainties of paragraph 5 to define upper and lower limits for its mean, \( \mu_{\text{max}} \) and \( -\mu_{\text{min}} \) thus obtaining two "worst-case" distributions. Use the confidence level of paragraph 2 to calculate corresponding uncertainties, \( u_+ \) and \( u_- \), according to the procedure of section 2.2 (see fig. 2). These overall uncertainties should be quoted together with 1) their systematic components, 2) their common random component, 3) the confidence level, and 4) any useful additional statistical information e.g., the number of degrees of freedom in calculated means or fitted curves (cf. Campion et al. [10]).

Although the responsibility for the views expressed above remains his alone, the author gratefully acknowledges his debt to many others with whom he has agreed or disagreed on the subject including Dr. K. G. Birch, Mr. J. E. Burns, Dr. P. J. Campion, Dr. E. Richard Cohen, Mrs. Mary C. Croakham, Prof. Jon Dorling, Dr. K. R. Eberhardt, Mr. D. R. Fisher, Prof. P. Giacomini, Dr. Donald A. Gillies, Dr. Harry H. Ku, Dr. K. T. Maslin, Dr. J. W. Mueller, Dr. B. W. Petley, Prof. H. R. Post, Dr. K. C. Shotton, Prof. J. Skakala, Dr. T. J. Quinn, Mr. F. J. Roberts and Prof. Dr. K. Weise.

References

LIAISON NEWS

LIAISON DELEGATE REPORT TO WESTERN EUROPEAN CALIBRATION COOPERATION (WECC)

The chairman of the WECC appointed the organization’s secretary Mr. John Wilson as the point of contact with NCSL. Through a letter dated October 8th, 1987, John Wilson provided the information on WECC. John is member delegate to the NCSL from NAMAS Executive British Calibration Services.

WECC is the forum for collaboration between calibration services in Western Europe. Its objective is to promote activities which will establish mutual confidence, leading to international agreements recognizing the capabilities of each other’s calibration services. The role objectives and activities of WECC appear in the enclosure (DOC 02-1987), WECC documents (DOC 01-1987) copy attached.

Certain members of the Board will recall my report on a visit paid to the accreditation organizations in the United Kingdom and Italy in September, 1986 by Dr. Andy Dunn, then of National Research Council of Canada, Ottawa, now Measurements International Ltd., Prescott, Ontario, Gary Hysert, Standards Council of Canada, Ottawa and myself. During these visits valuable discussions were held with John Wilson, National Physical Laboratory, Teddington, Middlesex and WECC President, Paolo Soardo of the Italian Service SIT. Copies of the WECC recommendations and guidelines referred to in the last paragraph of the enclosure were passed along to President Nemeroff. Copies are available from myself and our Canadian Secretariat Marilyn Ross for those interested.

John Wilson has asked for any information which he can circulate to WECC members. Could I have your inputs please.

Graham Cameron
Liaison Delegate to WECC

PMA LIAISON DELEGATE REPORT

PMA has accepted NCSL’s invitation to display the PMA Exhibit Booth at the 1987 NCSL Conference to be held in Washington, D. C. in August of 1988. Phil May, PMA Treasurer, has been delegated to make necessary arrangements with the chairman of the NCSL Exhibit Committee.

Distribution of the questionnaire for the proposed Directory of Metrologists is underway from the PMA National Office. The questionnaire initially will be sent to PMA members only.

The PMA Newsnotes is being restructured to include paid advertisements to partially cover the cost of printing. Publication is expected to be increased from semi-annually to quarterly.

Mr. Phillip A. Painchaud, Charter Life Senior Member of PMA, contributed several hundred dollars to start a special savings account with the stipulation that this money be used to establish a trust fund for the expressed purpose of fostering metrological education. Mr. Painchaud challenged others to make contributions to this cause. Additional contributions have been received. A trust fund is in the process of being established to meet the intended purpose.

Glenn E. Rasmussen
NCSL/PMA Liaison Delegate

1988 OIML CONFERENCE

The next quadrennial Conference for Legal Metrology will be held in Sydney, Australia in October, 1988. Approximately 20 new international recommendations (IRs) are expected to be sanctioned, with the USA being responsible for the following:


* Electronic Weighing Instruments (Provisionally adopted in 1986 as IR74) (PS7/R52).

* Non-Automatic Weighing Instruments (Compilation of IR 3, 28, 74) (PS7).


* Gas Chromatographs for Measuring Pesticides and Toxic Substances Pollution (PS17/R54).

* General Requirements for Prepackaged Products (PS20/R51).

* Verification of Net Contents in Packages (PS20).

WORK OF OIML PS23

This Secretariat is now titled “Measurement Standards and Devices Used for Calibration and Verification.” An International Working Group meeting was held in October, 1986 at which the title and scope of the work were refined. The U. S. participated in the meeting. The existing Pilot Secretariats of PS23 are:

efficiency of the 1931 CIE standard observer, and $K_m$ is the maximum spectral luminous efficacy which has been fixed as 683 lm/W by the new definition of the candela. The above expression holds for photopic light adaptation. Equivalent expressions, with $K_m$ and $V(\lambda)$ replaced by appropriate other quantities as defined by the CIE, apply for scotopic and mesopic adaption.

The main practical consequence of the 1979 candela definition and CIE equations is that they allow choices of physical methods for realizing photometric scales. For example, lamps calibrated as spectroradiometric standards can also be used as photometric standards once the above integral has been evaluated numerically. An alternative approach is the realization of photometric scales based on absolute detectors fitted with optical filters, so that the absolute spectral responsivity of the detector/filter combination represents the spectral luminous efficiency function $K_m V(\lambda)$.

The first of these approaches has been chosen by the National Bureau of Standards, which has supplied photometric standards derived from the BNS scale of spectral irradiance since 1979. The starting point of this derivation is the use of a gold point at color temperatures of 2800 K $\pm$ 30 K, under constant current conditions, and with fixed polarity.

After a first round of measurements, the participating laboratories shipped their lamps to the BIPM for comparison with the photometric standards maintained there. The BIPM then returned the lamps to the participants for repeat measurements.

The results of the intercomparison were presented at the 11th Session of the CCPR in October, 1986. They may be summarized as follows:

<table>
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<th>Candela</th>
<th>Lumen</th>
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<td>15</td>
<td>11</td>
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</table>

Number of participating national laboratories:

Average quotient of BIPM value (cd or lm) to values obtained by participating laboratories:

| 0.990 | 1.007 |

Standard deviation of the quotients:

| 0.77%  | 0.58%  |

Quotient of BIPM and NBS values:

| 0.985 | 0.997 |

The spread in the candela and lumen values reported by the national laboratories was slightly better than in previous intercomparisons. Because of the wider range of techniques now used for realizing photometric scales, this was seen as giving confidence to the new definition of the photometric base unit. Accordingly, the CCPR recommended:

"that, by 1st July, 1987, national laboratories make any necessary adjustment to the values attributed to their
standards used for representing and disseminating the candelas and the lumen in order to make them consistent with the definitions of these units."

"that by the same date, these laboratories advise the BIPM of the magnitudes of the adjustments made and of their best estimated of differences between their adjusted values and the mean value of the 1985 comparison."

Since NBS photometric scales have been based on the new candelas definition since 1979, no adjustment of the photometric standards maintained at the Bureau was necessary.

The intercomparisons revealed a discrepancy in the photometric scales maintained at the BIPM. According to the average quotients shown on lines 2 and 3 of the above table, the values attributed to the BIPM standards of luminous intensity were 1% lower than those corresponding to the mean candelas of the intercomparison.

ISO ON UNCERTAINTY

The International Standards Organization’s Technical Advisory Group ISO TAG 4/WG3 has proposed a Guidance Document on the "Expression of measurement uncertainty for use within standardization," calibration, laboratory accreditation and metrology services... The guidance is intended to be applicable to all fields of application and areas of metrology... as well as for various purposes at different metrology levels (e.g., research and high precision measurement applications, international comparisons... routine field or 'shopfloor' measurements, etc).

The IEEE Technical Committee TC-1 has been chartered to provide a forum for forming and collecting the opinion of the membership of the IEEE Instrumentation and Measurement Society with respect to the aforementioned Document. TC-1 is soliciting such opinions.

In order to provide the necessary background to the membership, TC-1 is preparing a short summary of the history and contents of the ISO TAG4/WG3’s preliminary draft. If you wish to receive a copy of this background material, and/or if you wish to express your opinion of the TAG 4 proposal, please contact:

Les Huntley MS169G
John Fluke Mfg. Co., Inc.
P.O. Box C9090
(206) 356-5088

PRESIDENT’S MESSAGE
(Continued from page 1)

b. Calibration Facilities Committee. Update and expand the existing RP.

c. Personnel Qualifications Committee. Exchange/develop job descriptions and qualifications for personnel from apprentices to managers. A potential result of the committee would be a Recommended Practice.


6. Explore organizational changes to enhance the effectiveness of the organization.

7. Increase committee productivity (output).

a. Develop and maintain a master roster of committee members.

b. Provided board recognition to committee members and promote their involvement to their sponsoring organizations.

c. Encourage concurrent committee meetings with Board of Directors meetings and Board Meeting participation by committee members.

d. Insure effective committee leadership through appropriate staffing of committee chairs.

8. Provide technical and/or financial impact analysis on lack of capability in the National Measurement System. Analysis to be provided to the NBS ans where requested to government bodies or other organizations that are in the interest of the membership or segments of the membership.

9. Explore development of special interest activities to serve segments of the membership (or potential membership) such as the Equipment Management Forum. This can be accomplished through existing committees such as Biomedical & Pharmaceutical Metrology and Utilities, and formation of new committees.

10. Initiate dialogue with government audit agencies to provide a forum for information exchange and problem identification/resolution. Included areas of concern are; specification interpretation, problem identification, mutual audit acceptance.

CHANGES IN UNITS

Several changes are expected to be effective January 1, 1990 that could impact many of us. They are changes in the volt, ohm, mass, and the international temperature scale. The approximate changes are:

- Volt – 9 PPM
- Ohm – 2 PPM
- Mass – 0.15 PPM

The temperature scale, ITS-90, will be defined for a wider temperature range beginning at 1 K (or possibly 0.5 K). Certain fixed points will be adopted as defining points and
improved values will be provided for the temperatures of the fixed points of the IPTS-68 that will be retained as part of the definition of the ITS-90. Interpolation devices for the different parts of the new scale will be specified. The accuracy of ITS-90 relative to the thermodynamic temperature scale will be substantially improved in comparison with the IPTS-68.

To help prepare us for the change three NCSL Ad-Hoc Committees have been formed. For additional information on these changes, or to serve on one or more of the committees (we need your help), please contact the committee chairman. Remember, you don’t have to be the NCSL member delegate to serve on NCSL committees:

91.4 Change in the Volt and OHM
Chairman: Norm Belecki
National Bureau of Standards
Bldg. 220, Room B258
Electricity Division
Gaithersburg, MD 20899
Phone (301) 975-4223

91.5 Change in the Unit of Mass
Chairman: Dr. Rich Davis
National Bureau of Standards
Physics Bldg., Room B160
Gaithersburg, MD 20899
Phone (301) 975-4215

91.6 Change in the International Temperature Scale
Chairman: Dr. Bill Mangum
National Bureau of Standards
Physics Bldg., Room B128
Gaithersburg, MD 20899
Phone (301) 975-4808

FEEDBACK OF OUT OF TOLERANCE DATA
An Ad-Hoc committee is being formed to study feedback of out of tolerance data. The stimulus for this committee is that feedback of out of tolerance information may have been imposed in subjective manner rather than an objective manner. Now that many organizations have been operating with feedback of out of tolerance systems, it would seem that data would be available for an objective analysis. Areas that will be considered by this committee include: policies, value added, definitions, cost, and results of in place programs. To serve on this committee, or if you need more information, or if you can supply data to the committee, please contact the committee chairman:

91.7 Feedback of Out of Tolerance Data
Chairman: Richard (Rick) Ailor
TRW O&SG
Building O2, Room 1305
Redondo Beach, CA 90278
Phone (213) 535-5606

NCSL SECRETARY RETIRES
With deep regret, on February 1, 1988, I accepted the resignation of Selwyn P. Smith as Secretary of NCSL, effective February 8, 1988. "Smitty" retired from GE Solid State on February 14, 1988. Holding the office of Secretary requires dedication and diligent attention to business at the Board of Directors meetings, and hours and hours of listening to audio tapes of Board meetings in order to transcribe the minutes of the meeting. "Smitty's" tireless efforts and contribution to NCSL are greatly appreciated. "Smitty" is planning on moving to California in the near future. On behalf of the Board of Directors and the membership, "Smitty", thank you. May your future be successful and happy.

Gary M Davidson,
President

Mr. Gary M. Davidson, President
National Conference of Standards Laboratories

Dear Gary,
I want to personally thank you and the NCSL for the contribution to the Algie Lance Living Memorial Trust Fund. This recognition of Algie's contributions to the Metrology community is especially valued from the major international "metrology" organization – NCSL.

The Algie Lance Memorial Trust has been established at UCLA in Los Angeles, CA. It will be used to support a graduate student(s) study and/or research in the measurement technology field. The topic and student selection will be made by TRW engineering management and UCLA professors.

Algie spent approximately thirty-three years directly in the metrology engineering field. He not only wanted to build up the metrology community from within, he realized and tried to demonstrate the importance of a good metrology organization to other engineering communities as well.

During his career, he was always a strong supporter of NCSL. I believe his greatest contribution was increasing the awareness and importance of "metrology" outside the metrology community. The Algie Lance Memorial Trust Fund concept was initiated by a TRW scientist within a major project organization. Much of the support for this initiative has come from the general engineering community. I believe this represents the success NCSL, and individuals like Algie, have had in making the general engineering community appreciate the contributions the metrology organizations can make to their programs. Metrology is no longer viewed as the "overhead" expense mandated by government contracts.

This contribution by NCSL will be viewed by the metrology and general engineering communities as evidence of the organization awareness of outstanding contributions to both.

Wendell D. Seal, Chairman
Algie Lance Living Memorial Trust
CALL FOR PAPERS
EQUIPMENT MANAGEMENT FORUM
Atlanta GA, September 29-30, 1988

The Equipment Management Forum (EMF), a standing committee of the National Conference of Standards Laboratories, is chartered "to promote cooperative efforts in advancing equipment management concepts through meetings, surveys, workshops, publications and other information exchange activities."

TOPICS OF INTEREST

Test Equipment Pools  
Redeployment of
  Equipment

Acquisition of Equipment  
Charge-back/Rental of
  Algorithms

Allocation Methods  
Financial/Funding
  Considerations

Leasing/Rental  
Utilization

Calibration Linkage  
Systems

Stuffing  
Excess Equipment

Obsolescence  
Structure

Control  
Ownership

Customer Interface/Support  
Standardization of Equipment

Vendor Feedback  
Resolution of
  Divergent Philosophies

AUTHORS/VENDORS/WORKSHOP DEVELOPERS
You are invited to participate in EMF No. 5 in Atlanta by presenting an original work on one of the suggested or related topics. Please notify Program Chairman of your intent and subject chosen by June 30, 1988. A 200 word (maximum) abstract should be received by the Program Chairman no later than July 31, 1988.

All material presented must be of general interest to the Equipment Management Community and non-commercial in nature. Referencing to specific products or services is considered inappropriate.

Send abstracts/workshop outlines to:
Ray Barrett, EMF Program Chairman
c/o Tektronix, Inc.
P. O. Box 500 – MS 45-000
Beaverton, OR (503) 627-1787

SIDES SPEAKS TO ENGINEERING CONFERENCE

EMF Chairman, Charlie Sides, was a guest speaker at the 15th Annual WATTeC Inter-disciplinary Technical Conference at Exhibition, February 16-19 in Oak Ridge, Tennessee. Charlie presented a paper entitled "The Equipment Management Forum of the National Conference of Standards Labs." Here is the published abstract of his paper:

Throughout corporate America, there is an emerging awareness that long-term survival mandates a change in the way management conducts its business. Today's highly competitive environment, both domestic and foreign, drives corporations to seek out significant productivity improvements while maintaining a competitive technical posture. This situation has accelerated the interest and focus for increasing the return of investments of physical capital assets through improved procurement selections and increased utilization. State-of-the-art asset management operations are tailored to support these objectives.

The Equipment Management Forum (EMF) was initiated in 1986 as a result of this environment and corporate America's interest in obtaining more knowledge of successful equipment management organizations, operations, and techniques. The EMF is therefore a strategic alliance of its active membership. This presentation provides an overview of the EMF. It will briefly define its parent organization, the National Conference of Standards Laboratories (NCSL), and how the EMF is postured within the NCSL. The historical evolution of the EMF will be described, including its present status and plans for the future. The EMF Steering Committee will be defined, as well as existing EMF publications and various committee outputs planned for the future. The EMF charter is "to promote cooperative efforts in advancing equipment management concepts through meetings, workshops, publications, surveys, and other information exchange activities."

WATTeC is a conference and exhibition held annually under the joint sponsorship of some 41 technical and professional societies in the East Tennessee Region. The conference is held annually during National Engineers Week observation. This year's conference registrants exceeded 1,200 including 40 commercial firms exhibiting products and services.

EQUIPMENT MANAGEMENT FORUM REPORT

Efforts are being focused on the special EMF Steering Committee meeting being held in part with the 1st Quarter NCSL Board of Directors meeting in Incline Village, Nevada. This joint meeting supports an objective defined at the October 1987 Board meeting, i.e., to increase visibility and strengthen communications between members of the Board and the membership of the active committees and NCSL regional participants. The agenda for the Board meeting has been structured to allow the EMP Steering Committee to meet jointly with the Board on February 1, 1988 at which time
the Committee will be introduced and can report its status to
the Board. Arrangements are being made for a separate
meeting room for the EMF Steering Committee to conduct its
independent sessions on February 2 and 3, 1988. This
committee meeting is considered a "foundation building
session" to establish the near term and long range goals, plans
and operations of the EMF.

Since the NCSL executive review has been completed to
resolve any conflicts between the NCSL By-Laws and the
EMF Administrative Guidelines Manual, an updated draft
version of the Guidelines will be reviewed page-by-page. The
committee will also review the EMF Long Range Plan in
detail.

Ray Barrett completed the St. Louis EMF write-up for input
to the NCSL Newsletter and it has been published in the
January 1988 release. Ray's write-up and Bill Martin's reports
on the Problems/Solutions Workshop have been sent to the
full EMF membership under my cover letter announcing
particulars of the next EMF (see enclosed).

Ken Pierce has been quite active in getting the first "EMF
Recommended Practice" on the road and will be addressing
this activity at the February meeting.

Tom McGovney recently accepted the position of Chairman
of the Business Systems Committee of the NCSL. Tom
informs me that he will continue in his EMF Steering
Committee position as Chairman of the Technical Issues
Subcommittee, and actually feels the two jobs will be
complimentary.

Tom has the pilot "EMF Bulletin Board System" in place and
has requested EMF Steering Committee members to exercise
the capability.

The attached chart provides the latest configuration and
staffing status of the EMF Steering Committee. New members
since my previous report are:

Financial Director:
Randy Seefeldt, Navy Primary Standards Lab
Automated Standards Subcommittee Chairman:
Chuck Van Winkle, DALFI, Inc.

I am actively seeking an EMF Steering Committee
appointment for the "East Regional Coordinator" and a host
for the 1988 EMF planned for the East Region in the late 3rd
quarter or early 4th quarter.

The next EMF is being held in San Diego on April 7 & 8,
1988. Randy Seefeldt of the Navy Primary Standards Lab is
host for this EMF, and a tour of the facility is scheduled for
the afternoon of Friday, April 8th. The Steering Committee
will meet the day prior to the Forum, i.e., April 6th.

C. A. Sides
Chairman, EMF Committee

EMF STEERING COMMITTEE REPORT

The EMF Steering Committee met at Incline Village, Nevada,
this past February 1, 2, and 3 in conjunction with the NCSL
Board of Directors first quarter meeting.

Ron Groom, Central Region Coordinator, reported that
Region Six does not have an NCSL coordinator and that he
felt a little "alone" in trying to promote the EMF.
Consequently, he is concentrating on his own company to
promote interest in the Forum.

Arnie Doll reported that the Directory Subcommittee was
developing a new format for the EMF Directory which would
include mail stop information for all listed addresses. He also
said that there would be an attempt to redefine the term
"Instrument Pool."

After break, Tom McGovney passed out copies of the
Technical Issues Subcommittee Report and instructions on
how to access the computer bulletin board he has set up in his
office. The committee discussed several of the ways the Board
of Directors could benefit the EMF. Tom reported he is also
working with Ken Armstrong, NCSL Secretariat, toward
facilitating the exchange of information at the NCSL level via
the bulletin board. Tom will be presenting a related report at
the Forum in San Diego, April 17th or 8th.

Chuck Van Winkle reported for the Automated Standards
Subcommittee that the data collected from his St. Louis EMF
Workshop is being analyzed for use in developing a straw
model for an Equipment Management System. He will
summarize the project to date during the continuation of his
workshop at the San Diego Forum.

The Newsletter Subcommittee Chairman presented a first draft
of the Subcommittee Charter for review. He also solicited
timely input of newsworthy EMF activities for future articles.

Next on the Steering Committee Agenda was the Forum
Facilitator's Report. Randy reported that all was in order and
on schedule for the San Diego Forum, April 7 & 8. The
Steering Committee will meet at 1:00 p.m. on the 6th to review and dispatch any last minute forum details (Charlie will release an agenda to all Steering Committee members approximately two weeks prior to the San Diego Forum, per EMF Administrative Guidelines Manual). Randy added that the location is ideal and the accommodations are great. Before leaving this agenda topic, the Committee selected the menu for Thursday's luncheon (included in the registration fee).

Next, and just before lunch, we began a review and discussion of the EMF Administrative Guidelines Manual. After lunch, we again took up the Guidelines Manual which consumed the balance of the day. It was decided, during these discussions, that the EMF organization needed an additional position to assist the Chair in developing the Forum Programs (future). Ray Barrett, Tektronix, will be assuming this task initially. The San Diego Forum is nearly complete so he will begin in earnest with the Atlanta Forum slated for October.

Wednesday morning we convened at 7:30 a.m. to take up the long range plan presented to the Steering Committee in St. Louis last October. As reported previously, this is a very ambitious, long range plan and worthy of considerable thought. Charlie will prepare a final draft for the Committee’s approval in April and will then present it to the NCSL Board at their third quarter meeting.

Ray Barrett
EMF Newsletter Subcommittee

**TWO THEORIES OF EXPERIMENTAL ERROR**

*(Continued from page 41)*


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<td>Andy's Bureau of Standards</td>
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<td>Andrew K. Dart</td>
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<td>Fresno, CA 93725</td>
<td>Simco Electronics</td>
<td>Vandenberg AFB, CA 93437-6318</td>
<td>Joel A. Treshansky</td>
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<td>Global-Wulfsberg</td>
<td>Prescott, AZ 86301</td>
<td>Richard Barnes</td>
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<td>Endevco</td>
<td>Roger J. Volk</td>
<td>San Juan Capistrano, CA 92675</td>
<td>Cornerstone Metrology</td>
<td>Sepulveda, CA 91343</td>
<td>Keith Chauvie</td>
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<td>Gates Energy Products</td>
<td>Terrelle J. Wilson</td>
<td>Warrensburg, MO 64093</td>
<td>McDonnell-Douglas</td>
<td>St. Louis, MO 63166-0516</td>
<td>Dean Yarolimek</td>
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<tr>
<td>Duquesne Light Co.</td>
<td>Charles Wittmer</td>
<td>Pittsburgh, PA 15233</td>
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December 30, 1987
Mr. Gary Davidson, President NCSL
Subject: Change in the NBS Unit of Mass

Since 1983 we have been engaged in an intensive review of the status of the working standard for NBS mass calibrations. This standard is based upon two nickel-chrome kilograms, N₁ and N₂. The steps that we have taken include:

* Return, in 1985 of the NBS primary kilogram standard (platinum–iridium prototypes K4 and K20) to BIPM in Sevres, France for verification.

* Development of an automated NBS kilogram comparator with sub-microgram precision.

* More rigorous assessment of the statistical uncertainty of calibration and the long term stability of the mass values assigned to the NBS N kilograms.

We have found that the mass values assigned to the N kilograms, that have been in use are larger than the SI value by about 0.15 ppm and we now plan to adjust the value of the NBS working standard for the kilogram to bring it into agreement with the SI value. The data of this change will be January 1, 1990, coinciding with changes in the SI values of certain electrical units and the practical temperature scale.

We believe that the change in the value of the kilogram disseminated by NBS will not have an important economic or technical impact upon users of NBS mass calibrations. Nevertheless, we suggest that the National Conference of Standard Laboratories (NCSL), jointly with the National Conference of Weights and Measures (NCWM), organize an ad-hoc committee to consider the need for user guidelines in connection with the change in the NBS value for the kilogram. We also propose that Dr. Richard S. Davis of the NBS Center for Basic Standards serve as an expert member of the ad-hoc committee. NBS will be pleased to publish an appropriate document resulting from the work of the committee.

The planned change in the U. S. value of kilogram will be compatible with improved quality assurance procedures that are being developed for the dissemination of NBS mass values to users throughout the United States. These procedures will be based upon an improved ensemble of NBS stainless steel kilogram check standards, automation of mass calibrations within NBS and an integrated measurement assurance mass transfer facility that provides improved controls for buoyancy corrections and factors that are influenced by operators in user laboratories.

If you desire more information regarding technical details of the planned change in the value of the kilogram to be disseminated by NBS effective January 1, 1990, please contact Dr. Rich Davis (301) 975-4215.

Arthur O. McCoubrey, Acting Chief
Length and Mass Division

December 31, 1987
Mr. Gary Davidson, President NCSL
Subject: Changes in the International Temperature Scale

In October, 1987 the 18th General Conference of Weights and Measures (CGPM, a formal diplomatic conference) adopted a resolution encouraging the International Conference of Weights and Measures (CIPM) and the national metrology laboratories (NBS and its counterpart laboratories) to complete the final details of a new temperature scale to replace the International Practical Temperature Scale of 1968 (IPTS-68). In taking this action, the CGPM anticipated that the new scale, ITS-90, could be officially put in place in all countries on 1 January 1990 following the publication of technical details during 1988. As you will recall, this date has also been designated for the introduction of revised electrical units.

The new temperature scale, ITS-90, will be defined for a wider temperature range beginning at 1 K (or possibly 0.5 K). Certain new fixed points will be adopted as defining points and improved values will be provided for the temperatures of the fixed points of the IPTS-68 that will be retained as part of the definition of the ITS-90. Interpolation devices for the different parts of the new scale will be specified. The accuracy of ITS-90 relative to the thermodynamic temperature scale will be substantially improved in comparison with the IPTS-68.

In accordance with the precedent already established for electrical units, we suggest that NCSL appoint an ad-hoc committee to consider the interests of the United States industry and government agencies that will be affected by the introduction of the ITS-90. We propose that the work of the ad-hoc committee be focused upon the development of appropriate guidelines for organizations that will be affected; in this connection, NBS will be pleased to publish such guidelines. Finally, we propose that Dr. Billy Mangum of the NBS Temperature and Pressure Division be appointed to the ad-hoc committee as the NBS technical expert and to provide such leadership as you may request. Dr. Mangum will be responsible for the dissemination of ITS-90 through calibration services.
Dr. Mangum would be pleased to provide additional technical information regarding ITS-90. In this connection he can be reached at (301) 975-4808.

Arthur O. McCoubrey, Acting Chief
Temperature and Pressure Division

MALCOLM BALDRIGE
NATIONAL QUALITY AWARD
PROGRAM FACT SHEET

AUTHORITY FOR AWARDS

Public Law 100–107, the Malcolm Baldrige National Quality Improvement Act of 1987, signed by President Reagan on August 20, 1987, establishes a U.S. National Quality Award.

Secretary of Commerce and National Bureau of Standards are given the responsibilities to develop and administer Awards with funding from the private sector.

KEY PROVISIONS OF P. L. 100–107

Categories for Awards: 1. companies or subsidiaries; 2. small businesses; and 3. service companies. Up to two Awards may be given each year in each of these categories.

Criteria for Qualification: Apply in writing to Director, NBS; and permit rigorous evaluation.

Awards: Medal bearing inscription "Malcolm Baldrige National Quality Award" presented by the President or the Secretary of Commerce. Award recipients may publicize and advertise based upon Awards.

Award Examination: NBS shall rely upon a Board of Examiners which shall conduct reviews and site visits.

Technology Transfer: NBS Director shall ensure feedback to applicants and publicize successful quality improvement strategies.

Award Program Oversight: Secretary of Commerce shall appoint prestigious Board of Overseers to review Award process.

Funding: Secretary of Commerce is authorized to seek and accept gifts and to impose fees upon applicants.

AWARD PROGRAM PLAN

Presentation of Awards
Awards will be presented by the President at an Awards ceremony in November, 1988.

Eligibility
Businesses incorporated and located in the U.S., and either privately or publicly owned

- Categories:
  * companies - manufacturers of goods, mining, construction, agriculture (SIC Codes 01 to 39).

Criteria
* Includes quality process, continuous quality improvement, and customer satisfaction
* Specific examination areas: 1. leadership; 2. information and analysis; 3. planning; 4. human resource utilization; 5. quality assurance of products and services; 6. quality improvement results; and 7. customer satisfaction.

Application Process and Review:
1. Written application responding to detailed questions in seven criteria areas.
2. Screening of each application by three Examiners to select finalists.
3. Site visit and customer satisfaction examinations of finalists. Detailed site visit requirements will be set by the Board of Examiners.
4. Board of Examiner review of all data and information to recommend Award recipients.

Timetable
* Applications will be available from NBS by February 15, 1988.
* Applications must be filed by May 1, 1988. An application fee of not more than $1500 will be charged. The exact fee will be set when applications become available.
* Applications will be reviewed and site visits conducted between May 1 and September 30, 1988. Finalists will be notified of site visits and site visit fees at least three weeks in advance of visits.
* An Award Ceremony will be held in mid November, 1988.

Recipients will be notified approximately six weeks in advance of the ceremony.

AWARD PROGRAM CONTACT

Dr. Curt W. Reimann
Malcolm Baldrige National Quality Award
National Bureau of Standards
Gaithersburg, MD 20899
(301) 975-2036

ELECTRONIC PUBLISHING LAB OPENS AT NBS

The Electronic Publishing Laboratory in the NBS Institute for Computer Sciences and Technology officially opened on October 30. The lab will be used by NBS to gain a better understanding of the technologies underlying electronic
publishing, to help develop standard and guidelines, and as a showcase for government agencies to evaluate desktop publishing systems. Twenty-four companies have either loaned or donated software and equipment. For further information, contact Lynne Rosenthal, Institute for Computer Sciences and Technology, B266 Technology Bldg., National Bureau of Standards, Gaithersburg, Md. 20899, telephone: (301) 975-3353.

CONTACT: Jan Kosko, (301) 975-2762

MASS FLOW METERING STANDARDS ADDED TO HANDBOOK 44-1988

The producers and distributors of fuels, lubricants, and petrochemicals will be interested in the changes made to the codes for "Liquid Measuring Devices" and "Liquid Petroleum Gas (LPG) and Ammonia Liquid Measuring Devices," in NBS Handbook 44-1988, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices. The National Conference on Weights and Measures (NCWM) adopted the standards at its 72nd annual meeting to recognize the use of mass flow metering systems. Mass flow metering systems that are affected by changes in the density of product being measured must incorporate an automatic means to determine product density and correct for changes in density while the product is being measured. The tolerances for mass flow meters are consistent with those for other meters used in the same application. Copies of NBS Handbook 44-1988 are available for $15 prepaid from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Order by stock no. 003-003-02820-7.

CONTACT: Roger Rensberger, (301) 975-2762

NBS PUBLISHES 1988-89 CATALOG OF STANDARD REFERENCE MATERIALS

NBS Standard Reference Materials Catalog 1988-89 (SP260), lists nearly 1,000 standard reference materials (SRMs) available from the Commerce Department's National Bureau of Standards (NBS).

The SRMs, certified by NBS for specific chemical and physical properties, help scientific, industrial, and commercial users to achieve quality assurance of materials and goods. These materials include cements, ores, metals, glass, plastics, food, environmental, and clinical items.

The new catalog also has an expanded list of nutrition and health standards. The new SRMs include materials to calibrate instruments that detect marijuana in human urine sample (SRM 1507), to measure cholesterol in human blood serum (SRMs 1951 and 1952), to measure fat-soluble vitamins and cholesterol in food products (SRM 1563), and to improve the precision of tests for elevated levels of the enzyme aspartate aminotransferase (AST) to detect heart attacks, congestive heart failure, hepatitis, and liver disease (SRM 8430).

Copies of the new catalog are available from the Office of Standard Reference Materials, B311 Chemistry Bldg., National Bureau of Standards, Gaithersburg, Md. 20899, telephone: (301) 975-OSRM (6776).

OFFICIALS BREAK GROUND FOR NBS "COLD NEUTRON" FACILITY

 Officials of the U. S. Department of Commerce and the National Bureau of Standards (NBS) broke ground Friday, November 20, for a $25 million cold neutron research facility, the first in the United States and one of the foremost of its type in the world. Deputy Secretary of Commerce Clarence J. Brown, NBS Director Ernest Ambler, and Maryland Congresswoman Connie Morella participated in the ceremony at the NBS Research Reactor site in Gaithersburg, Md. "Cold" neutrons are low-temperature, hence low-energy, neutrons produced by specially designed nuclear reactors. Cold neutron sources have become one of the most-desired tools of modern materials research, because they allow researchers to conduct experiments that would be impractical or even possible with more energetic neutron sources. Typical areas of application include the design of high-temperature, high-strength ceramics for engines; the study of improved semiconductor devices; the development of new magnetic alloys for more efficient electric motors; the creation of new chemical catalysts; and the precision measurement of newly "engineered" biomolecules.

CONTACT: Michael Baum, (301) 975-2762

DETAILS NOW AVAILABLE ON SUPERCONDUCTING CONTACTS

The high resistance that usually occurs where external leads are attached to ceramic superconductors is an obstacle to both measurements and practical applications of the newly developed high-critical-temperature superconductors. Work by NBS and the Westinghouse Research and Development Center, Pittsburgh, Pa., has produced a new method for making low-resistance electrical contacts on ceramic superconductors. The researchers developed the new method after noticing there was a correlation between the ages of many superconductor samples and their contact resistivities. The new method involves three parts, which work together to produce low contact resistivity. Minimizing the air exposure time minimizes the degradation of the superconductor surface that occurs before making the contacts. Sputter etching the surface removes the degraded layer, and depositing a thin layer of a noble metal - silver and gold were used - protects the surface and minimizes further degradation of the
superconductor surface. When the method was tried on old samples exposed to air for over 2 months, the contact resistivity was about 10 times higher than for contacts formed on fresh samples only an hour old. A deeper sputter etch may be necessary for superconductors having long exposure to air. For the particular superconductor tested, bulk YBa$_2$Cu$_3$O$_7$ the sample was etched to a depth of 20 to 50 nanometers at 1.25 kV rms in 3- Pa argon for about 3 minutes. A 1- to 6-micrometers-thick contact pad was immediately sputtered onto the surface (4.2 kV rms, no applied bias), also under an argon atmosphere. The superconductor temperature was held to less than 100 degrees Celsius with a water-cooled sample holder. For information, contact: Jack Ekin, Electromagnetic Technology Division, National Bureau of Standards, Boulder, Colo. 80303, telephone: (303) 497-5448.

CONTACT: Collier Smith, (303) 497-3198

NBS AUTOMATION RESEARCH OPEN HOUSE ATTRACTS 500-PLUS

More than 500 representatives from industry, universities, and government agencies – including many defense organizations – attended an open house at NBS spotlighting the bureau’s automation research. For the past several years NBS has hosted tours and presentations on the NBS Automated Manufacturing Research Facility (AMRF). These events have provided an excellent tool for technology transfer of research developments at the AMRF. This year, the event was expanded to include automation research activities and services not directly covered at the AMRF. A fact sheet on the AMRF facility is available to reporters from the Public Information Division, A903 Administration Bldg., National Bureau of Standards, Gaithersburg, Md. 20899, telephone: (301) 975-2762.

CONTACT: Michael Baum, (301) 975-2762

PRESIDENT SIGNS COMPUTER SECURITY ACT

On Jan. 8, President Reagan signed the Computer Security Act of 1987 (P. L. 100-235) giving NBS the primary responsibility for developing standards and guidelines needed to secure sensitive, unclassified information in federal computer systems. In addition, the act amends the basic charter of NBS and mandates a computer standards program within NBS. (Since 1966, under the Brooks Act and policy directives from the Office of Management and Budget, the NBS Institute for Computer Sciences and Technology has conducted a standards program for the federal government which included computer security activities.) The Computer Security Act leaves unchanged the National Security Agency’s (NSA) authority over computer systems containing classified, national security-related information. NBS will continue to work closely with NSA and to draw upon the agency’s technical advice and assistance where appropriate.

CONTACT: Jan Kosko, (301) 975-2762

BELL COMMUNICATIONS WORKING WITH NBS ON ISDN

Venky Basapur, a researcher from Bell communications Research, is working with researchers in the NBS Institute for Computer Sciences and Technology to help develop standards and test methods for the Integrated Services Digital Network (ISDN). (Bell Communications Research is the research and development arm of the seven regional Bell holding companies.) ISDN is a new telecommunications technology that makes it possible to send and receive voice, data, and image signals simultaneously over digital telephone networks. NBS is working with private industry, research laboratories, and other federal agencies to set up an ISDN laboratory using donated equipment and services. Basapur will be at NBS for at least a year as part of the bureau’s long-standing Research Associate Program. This program provides an opportunity for engineers and scientists from industry, technical societies, and other organizations to conduct cooperative research at the bureau on projects of mutual interest with salaries paid by the sponsor.

CONTACT: Jan Kosko, (301) 975-2762

NEW PATENT COVERS 3-D LASER MEASUREMENT SYSTEM

NBS researchers have received a patent for an automated laser tracking system that greatly simplifies the tasks of accurately measuring the dimensions of large shapes, such as aircraft wings or fuel tanks. The five-axis laser tracking system invented by Kam Lau and Robert Hocken of the NBS Center for Manufacturing Engineering includes a laser interferometer, a servo-controlled tracking mirror, a similar target mirror, and a computer to control the system. Once the laser is "locked" on the target mirror, the control system keeps the beam centered on the target as it is moved about the space to be measured. The interferometer constantly returns displacement measurements to the controller, and angle-sensitive transducers on the tracking and target mirrors send the data necessary for the computer to keep a running account of the three-dimensional position, pitch, and roll of the target mirror. A simpler 3-axis system, also covered by this patent, measures the position of the target without pitch and roll. The system is portable, fully automated, uses only one station, and can measure positions over a sizeable volume (a radius of 20 meters or greater over 360° in the horizontal and + 40° in the vertical) to an accuracy of about one part in 100,000. This is about 3 times better than a close competitor: a multi-station, computer-assisted theodolite system (also invented at NBS). Other applications include assessing the static and dynamic performance of robot arms and the accuracy of machine tools and coordinate measuring machines. The system is being marketed by Automated Precision, Inc., 7901-C Cessna Avenue, gaithersburg, Md. 20879.

CONTACT: Michael Baum, (301) 975-2762
NBS, COMPUTERVISION BEGIN JOINT CAD/CIM PROJECT

NBS and Computervision Corporation have begun a three-year joint research effort to study the integration of computer-aided design (CAD) systems with computer-integrated manufacturing (CIM) control systems. The project will use CADD Stations (DAD workstations) and 2-3-dimensional CADDx4 software provided by Computervision, and the NBS Automated Manufacturing Research Facility (AMRF). NBS and Computervision researchers will concentrate on the preparation of manufacturing data and management of information on the product life cycle for manufacturing activities. The work will include basic research on managing manufacturing data and the use of the emerging Product Data Exchange Specification (PDES) standard.

CONTACT: Michael Baum, (301) 975-2762

NBS-EMD JOINT PROJECT ON MEASURING MACHINE PROBES

NBS and Electronic Measuring Devices, Inc. (EMD) of Flanders, N. J., have begun a joint research project aimed at improving the accuracy of the probes used on advanced coordinate measuring machines (CMMs). At present, the accuracy of these widely used dimensional measurement tools is limited by the accuracy of the electromechanical probes that they use to sense the surface of an object. The next generation of CMMs with accuracies below 1 micrometer will require much more accurate probes, but there are no generally accepted methods of analyzing and testing the performance of these probes—particularly the newer analog probes. The NBS Center for Manufacturing Engineering is working to develop the necessary test equipment and methodology. Under a recently signed agreement, EMD, a manufacturer of advance CMM probes, will lend NBS an experimental probe and related equipment, and EMD researcher Dr. Klaus Ulbrich will work with the bureau to develop methods of characterizing the performance of these probes and standard techniques to integrate the probe into the operation of a CMM.

CONTACT: Michael Baum, (301) 975-2762

REPORT OUTLINES STUDY ON DECAY OF ARCHIVAL RECORDS

Librarians and archivists concerned with the degradation of paper materials stored in containers will be interested in The Characterization of Microenvironments and the Degradation of Archival Records: A Research Program (NBSIR 87-3635). The report was prepared by NBS for the National Archives and Records Administration (NARA) at the suggestion of a National Academy of Sciences (NAS) committee convened to study the preservation of historical records. NAR recommended that NARA conduct a study of archival containers and microenvironments, including boxes, folders, and polyester encapsulation to understand the maximum benefits from particular materials and designs. The NBS report describes the issues involved in assessing materials. Some examples are given to illustrate how air pollutants can be exchanged between the inside and outside of containers by diffusion through container walls or through gaps and openings, and by the effects of pressure and temperature changes. The problems of complete sealing or encapsulations of documents are discussed because of the possibility of autocatalytic degradation. Copies of NBSIR 87-3635 are available prepaid for $19.95 from the National Technical Information Service, Springfield, VA. 22161. Order by BB #88-128996.

CONTACT: Roger Rensberger, (301) 975-2762

FY 1989 BUDGET PROPOSES INCREASES FOR NBS

The President's budget proposal to Congress for Fiscal Year 1989 includes $158.039 million for NBS. This compares with $144.783 million appropriated for FY 1988. The FY 1989 research programs at NBS will reflect the Bureau's increasing emphasis on improving the U.S. position in international competition. Included in the request are increases in several areas. These include $3 million for NBS to carry out its new responsibilities under the Computer Security Act of 1987. NBS would receive $6.5 million (in addition to an FY 1988 increase of $4.8 million) to enable NBS to provide American industry with research findings and the measurement capability needed to develop and commercialize products based on new high-temperature superconductors. Other increases are proposed for: chemical process control and quality assurance ($2.5 million), lightweight measurement technology—fiber optics ($3 million), high-performance composites ($1 million), bioprocess engineering ($2.5 million), and the Thomas A. Edison Prize ($4 million) for inventors. Also a $5-million decrease would eliminate funding for Regional Centers for the Transfer of Manufacturing Technology, with the centers operating on funding provided at the end of FY 1988. A decrease of $3.872 million in the FY 1989 budget reflects a proposed combination of the NBS Centers for Fire Research and Building Technology.

CONTACT: Mat Heyman, (301) 975-2762
ESL Incorporated
A subsidiary of TRW
Sunnyvale, California
Host: Paul P. Chong

Paul P. Chong, Manager, Instrument Services

ESL specializes in the design, development, and production of electronic systems and related products for the U.S. Government tactical and strategic reconnaissance markets, and in rendering services to analyze reconnaissance data and conceive new reconnaissance systems. This unique combination and synergy of skills has made ESL one of the country’s premier reconnaissance systems contractors.

Employing over 2,700, ESL is a wholly owned subsidiary of TRW Inc., and is a unit of the Defense Systems Group in the TRW Space and Defense Sector. ESL is the largest TRW operation in Silicon Valley with approximately 300 active contracts annually.

The ESL staff occupies close to a million square feet of R&D facilities in four locations - headquarters and primary R&D are in Sunnyvale and San Jose, CA and engineering and systems development facilities are in Reston, VA; Hanover, MD and Murray, Utah.

ESL consists of three divisions, Advanced Military Systems Division; Signals, Analysis and Systems Division; and Defense Research Systems Division.

ESL is a MIL-Q-9858A house.

Instrument Services was organized to provide a cost-effective system of control over the maintenance, calibration and repair activities for measuring devices and test equipment used in the fulfillment of company and contractual quality requirements.

CORPORATE RELATIONSHIPS

OPERATIONAL FLOWCHART

EQUIPMENT SUPPORT SECTION

The Equipment Support Section acts as a clearing house for all service requests and equipment user needs.

The Equipment Support Section also provides direct interface with outside support organizations.
Lee Blackshire is verifying the return date from an outside vendor.

With the help of the corporate IBM 3090 computer system, an on-line Asset Management System is used to provide a calibration recall system, asset listings sorted by any available fields of information, and real-time ad-hoc reports upon request.

Louis Kendricks is easing his vehicle into a reserved parking space used to load, or off load, equipment scheduled for service from our outlying buildings.

A panel truck is used to provide equipment pickup and delivery services to corporate organizations and three operating divisions at twelve local area remote locations.

Donna Winton is refileing the metrology service records after service has been completed.

The Equipment Support section maintains the metrology service record system in compliance with MIL-STD-45662.

Rick Grambsch is verifying the calibration status on the SITE equipment.

A short term equipment pool (STEP) is operated for QRC (quick reaction) needs and to reduce requirements for outside equipment rentals for brief periods.

Personnel in this section are our front line troops. They help to set the tone of services provided.

**METROLOGY SERVICES SECTION**

The Metrology Services section performs or provides maintenance, calibration and repair services in a cost-effective manner. Besides this key role, it also provides assistance to the equipment user community on matters related to measurement technology and equipment serviceability.
It is fortuitous that all personnel working in this section are FMEL graduates.

The Metrology services section is divided into two areas of responsibilities; dimensional measuring devices/tooling and electrical/electronic test and measurement equipment.

Both areas employ a wide variety of measurement standards traceable to the National Bureau of Standards or universally accepted measurement systems through an unbroken chain of comparisons.

**Overview of Lab**

Good housekeeping practices, a dedicated air conditioner and bench lighting are controlled to the extent necessary to maintain a proper working environment and provide a clean, well-lighted work area.

Some documents that govern our Metrology Services operation are MIL-STD-45662, internal operating procedures and U. S. Air Force TO 33K-1-100.

**DEDICATED POWER**

An Emergency Power Engineering model 48TI2-50 line conditioner is used to provide clean power to our workstations from a dedicated line from the local utility company. House power is only used for backup.

**REPLACEMENT PARTS**

An 1800 line item, computerized replacement parts system provides cross-reference information, parts location and reorder levels to minimize equipment down times.

F. "Dan" Dancisin, section supervisor, verifies service priorities.
WORKSTATIONS

Waveform troubleshooting and servicing. Bob Hall is checking the reproduction fidelity of the recorded signal on HP 3964A instrumentation recorder.

Time and Frequency. Ann Garrison is using a HP3325A synthesizer/function generator to check the frequency response on a HP5333A, universal counter.

Voltage, current and impedance. Ken Smith is using an ESI RV722 precision decade voltage divider to calibrate a HP 3455A, digital voltmeter

Dimensional. Jeny Abbott is using a Brown & Sharpe 599-970-11, gage block comparator, to verify a set of Mitutoyo Gage Blocks.

Computer-aided testing (CAT). Phil Kirsch is using the HP9000 series model 310 controller to calibrate HP 8481A power sensors.

Dimensional. Jerry Abbott is observing Ann Garrison’s techniques in using the 500 foot/pound Acratork L35 torque analyser.
MEETING NOTICE
EQUIPMENT MANAGEMENT FORUM
MARK YOUR CALENDAR!

Date: April 7-8, 1988
Place: San Diego, California, (Doubletree Hotel)
Host: Randy Seefeldt – Navy Primary Standards Labs

Information and registration materials are attached.

Charlie Sides
Chairman – EMF Committee
Boeing Aerospace Company
(206) 773-9944

REGION 6 EDUCATION MEETING

March 16, 1987 Meeting on Measurement and Metrology
Held at Texas A&M University, Bryan-College Station, Texas.

This is a report of the first meeting on Measurement and
Metrology held at Texas A&M University. The meeting was
sponsored by the Department of Engineering Technology.
The purpose of the meeting was to assemble interested
industrial and academic representatives to discuss the need for
reemphasizing measurement, metrology, and standards in
engineering and engineering technology programs at Texas
A&M University.

Attendees from industry were:
Bob Willett (Rockwell)
Earl Murphy (General Dynamics)
Joe Brown (Data Marketing Associates)
Ron Groom (AT&T)
Kathy Lowes (AT&T)
Greg McElveya (Hewlett-Packard)
Dave Schneider (Lockheed)
Tommy Weaver (Tracor)
Bob Ellis (Austron)

Invited-Interested / Did not Attend
Clyde Orrison (Texas Instruments)
Randy Wear (Fluke)
Don McKenzie (Tektronix)
Brannin McNeil (E-Systems)
Luis Diaz (LTV)
Ken Moore (Thompson Corporation)

Attendees from Texas A&M were:
Robert Benson (Dept. of Engineering Technology)
Bill Grubbs (Dept. of Engineering Technology)
John Weese (Dept. of Engineering Technology)
Tim Coppinger (Dept. of Engineering Technology)
Jerry Wickman (Dept. of Engineering Technology)
Peter VanPeteghem (Electrical Engineering)
Chris Burger (Mechanical Engineering)

Objectives of the meeting were:

• To identify concerns by industrial representatives regarding
  the competencies of graduates in the area of measurements,
  metrology, and standards;
• Discuss how important measurements concepts could be
  integrated into all laboratory exercises involving
  measurements;
• Discuss what topics should be included in a course
  specifically designed to provide educational competency
  and skill in the area of measurements;
• And to establish a network of industrial and academic
  representatives to provide a continuing interaction.

The engineering facility presented several reports on the
current status of measurement and metrology at Texas A&M
University followed by reports concerning plans for the future
incorporation of metrology into the various engineering
curricula.

There was considerable discussion on the expected future on
metrology in industry. Some attendees believed that metrology
as practiced today will disappear in the future. Others held
that the secondary standards lab and the metrologist were
here to stay.

The industry representatives made several suggestions
concerning our planned course in metrology. They strongly
feel that the concepts of metrology should be emphasized in
all lab-oriented courses taught in engineering. They believe
that the basic definitions should be clarified early in the
student's education.

The industry representatives suggested that bringing in experts
from the field of metrology to interact with the students would
be important. The representatives expressed concern that the
faculty would not be qualified to teach metrology as it is
needed in industry. Most of the faculty would not be qualified
to teach metrology as it is needed in industry. Most of the
faculty has had little direct experience in the field of
metrology.
The representatives believe that the faculty should be involved in the NCSL and other related groups, that the faculty should be trained in the current standards and practices of metrology by attending seminars and workshops, and that the engineering departments should acquire the instrumentation required to properly teach the subject.

The meeting closed with a request that attendees submit a list of top five metrology items they think should be included in the engineering technology curriculum. At this time only two responses have been received.

Results of the meeting:
* A college-level course in metrology is being planned at Texas A&M University for the Spring of 1988.
* Dr. Robert Benson attended the Spring meeting of the NCSL (Region 6) held at John Fluke in Dallas, Texas.
* Dr. Robert Benson attended Fluke's five-day "Metrology for Technicians" course held in Dallas during May, 1987.
* A follow-up meeting for the Fall is being planned to discuss the results of our efforts toward the inclusion of metrology in the Electronics Engineering Technology Curriculum.

Robert Benson
Department of Engineering Technology
Texas A&M University
College Station, Texas 77843
(409) 845-5195

EDUCATION AND LIAISON REPORT

As a result of NASA Lewis concern regarding the lack of Metrology Technicians in the local area, Cortez III personnel Frank Della Torre, Joe Millin and myself held conversations with local institutions concerning the possibility of starting Metrology Programs.

We talked to three institutions; the University of Akron, Cuyahoga Community College and Lorain Community College. Before seeing them, I had called Herb O'Neil at Hutchinson and Donald Drum at Butler, and they assured me of their willingness to talk to any institution interested in a Metrology Program.

Akron has an already developed and state approved instrumentation course which is inactive due to lack of students. Modifying and renaming this would be possible. However, they felt they could not make any recruiting efforts for the program and would need guarantees of 12 to 15 students per year plus the cooperation of industry in furnishing a laboratory.

Cuyahoga Community College is also interested. They would have no difficulty in recruiting students, but they need to show sufficient local market for the students at least in the state.

They would require assistance in developing curriculum, obtaining equipment and recruiting instructors.

Lorain Community College has already been considering a Metrology Program. They would need help in conducting a marketing survey but may be able to justify a nation-wide market. They also require participation on an advisory committee, assistance in determining curriculum student competency level, program content and assistance in obtaining equipment.

At this time we are discussing the results with NASA in an effort to determine what level of support they can commit to a program.

Kate Webster
Committee Chairman

BUSINESS SYSTEM COMMITTEE REPORT

After my appointment to Chairman of the Business System Committee, I met with Roland Vavken to discuss my chairmanship responsibilities and current activities with the Committee. Roland introduced me to Dave Cotton who is the individual that has been doing most of the recent programming for the NCSL computer based Business System located on the Secretariat's computer. After meeting with Roland Vavken and Dave Cotton I contacted Ken Armstrong to discuss the many facets of the Secretariat's computer system. During my discussion with Ken (including follow-up letters from Ken) we covered the subject of possible enhancement to his current computer based Business System. The enhancements dealt mostly with increasing speed of the computer processing time and not a change in procedure. Presently, Dave Cotton is upgrading the business system from Ashton Tate's Dbase II to Dbase III Plus. This upgrade provides built-in enhancement that will most likely improve the speed and operation of the current Business System. Dave estimated a completion of the upgrade by mid-February, 1988. I suggest that we wait until after the upgrade has been installed before we work on further enhancements.

Other areas of interest for the Business Systems Committee is the possibility of setting up an electronic bulletin board and developing a method of remote access to some of the data residing on the Secretariat computer. Prior to my appointment to the Business System Committee I had been developing an electronic bulletin board for the NCSL's Equipment Management Forum Committee. Presently I have installed and partly customized a third party bulletin board that is running in a background mode on my IBM AT TRW. The bulletin board has recently been expanded to include an area for the NCSL and its Board of Directors (BOD). To facilitate the customizing and ultimately the feasibility of maintaining a bulletin board I am requesting that the NCSL BOD familiarize themselves with the bulletin board and use it
on a regular basis. To facilitate the use of the bulletin board I am attaching a brief overview of its operation.

Starting in 1988 our department will be making a study on how to access and process data base searches remotely. The results of this study will be beneficial in determining the feasibility of doing the same for the NCSL Business System's data. I hope to be able to report on this study with respect to the NCSL's requirements by the August BOD meeting.

G. T. McGovney, Chairman
Business System Committee

ADJUNCT TRAINING COMMITTEE REPORT

1. Sent letters to all Regional Directors and Coordinators requesting volunteers to serve on the Adjunct Training committee. To date I have received positive inputs from regions 2, 5, 6 & 8. I will send letters of appreciation to these individuals during the first quarter of 1988.

I expect further volunteers as the other regional/sectional meeting are conducted.

2. The cost for video tape splicing is approximately $25.00/tape. This was an open item from our last discussion.

3. I still plan to meet with Dave Workman, at the MSC, to discuss possible PMA involvement with Adjunct Training. I will brief you on the results sometime in February, 1988.

4. I still have not received any published Adjunct Training materials. I solicit the help of the board in making this an action item during the next Board of Directors meeting.

In closing, I will be attending the next Board meeting to present my report for Adjunct Training and Bob Willett's report for Region 6.

Bill Doyle
Committee Chairman

STANDING COMMITTEES SUGGESTION

1. Calibration Procedures Committee. This area needs a committee which has recommended methodology and practices as its primary goal. Identification and sharing of procedures, workshops on new, novel calibration techniques and the updating of RP-3 from the Product Design and Specification Committee (Guideline 53.0) and having that a committee focus its efforts on recommended practices for specification and evaluation of test equipment and calibration standards.

2. Standards and Calibration Facilities Committee. Although we have a new recommended practice in this area, based on the inputs received we need to update and expand this document to be more specific and cover other requirements.

3. Metrology Personnel Qualifications Committee. This committee could be a new one or an added function of an existing education/training committee. The idea is to develop and exchange information on job descriptions and qualifications for metrology and calibration personnel from apprentices to managers. This could lead to a recommended practice on at least how to establish requirements, information to guide development of job descriptions and qualification requirements and samples. This information could facilitate improved salary surveys also.

4. Calibration Report Committee. This committee can focus on exchanging information on error analysis, measurement uncertainty expression and reports (certificates) of calibration. This should lead to development of related recommended practices and if the committee is implemented now, we may have a better impact on the international efforts going on now in this area.

D. H. Caldwell
Executive Vice President

AD-HOC COMMITTEE ON INTRINSIC STANDARDS REPORTS

Membership for the ad-hoc committee on intrinsic standards has been finalized. The following people have agreed to participate:

Industry: Dr. K. Jaeger, Chairman (Lockheed Company)
Mr. L. Huntley (John Fluke Company)

NBS: Dr. J. Simmons (Gaithersburg)
Dr. R. Judish (Boulder)

DoD: Mr. F. Flynn (Newark Air Force Station)
Mr. J. Ball (Army TMDE Support Group, Redstone Arsenal)
Pending (Navy)

The first meeting has been scheduled for January 27, 1988.

Klaus B. Jaeger Chairman, Ad-Hoc Committee on Intrinsic Standards
REPORTS FROM THE REGIONS

Nancy Thomas, Regional Editor, Hewlett Packard
(415) 857-5197; FAX (415) 857-5518

REGION 2

Oct 21, 1987
Loral Electronic Systems
Bronx, NY
Bill Brenant, Coordinator, Region 2

Due to the extremely bad weather, we were late getting started. The meeting was started with welcoming remarks by Bill Brenant, host, and a short NCSL update. Dr. Joe Simmons of NBS was introduced. He gave a very informative talk on NCSL, NBS, going forward. We had a brief introduction and overview from J. Singleton and J. Savidge of Eastman Kodak Co.

Lunch was provided by Loral. There was a test equipment exhibit demonstration by Tektronix Instrument Division.

The products, all designed and built by Tektronix, included:
* Digital Storage Oscilloscopes
* Laboratory Oscilloscopes
* Programmable Instruments
* Spectrum Analyzers
* Digital Analysis Systems
* Logic Analyzers
* PEP 301 Systems Controller

The meeting concluded with a roundtable problem discussion.

Bill Brenant welcomes Region 2 members to Oct. 12th meeting

REGION 3-4

October, 1987
Marriott Gwinnett Pl
Orlando, FL
Anthony Anderson
Director, Regions 3 & 4

At the end of October Region 4 held the first meeting of the new Atlanta Section at the Marriott Gwinnett Place. The meeting was very well attended with 31 attendees and totally justified the decision to form a new section in this part of the Region. The meeting was both lively and informative and further meetings in the area seem assured of success. I would like to thank Sam Tolbert our new section co-ordinator and John Riley for their efforts for organizing an excellent meeting.

At the turn of the year John Riley, after many years as Region 4 co-ordinator, stepped down and Woody Tramel now assumes his responsibilities. However, John will still be as active as ever in Region 4 since he now becomes the new section co-ordinator for Central Florida. Many thanks John for your past efforts and success with the new section.

In Region 3 Marlin Johnson is picking up the reins after a year where unfortunately there has been little activity, due to the absence of a regional co-ordinator. Meetings have now been scheduled for March 31st at Johns Hopkins APL in Laurel, Maryland and for October 13th at NASA Langley. This year should see Region 3 achieve a better level of activity.

REGION 5

Dec. 3, 1987
Monsanto Research Corp
Miamisburg, Ohio
Max Green
Southern Ohio/Kentucky Section Coordinator, Region 5

The meeting was hosted by Richard Shaffer and his member company, Monsanto Research Corporation, Mound Facility, Miamisburg, Ohio. There were thirty-eight attendees representing sixteen corporations from four states.

The meeting was opened by Max Green presenting an introduction to the day's agenda and turning the meeting over to our host, Richard Shaffer, Monsanto Research Corporation. The Mound Facility is a Government owned installation operated for the Department of Energy (DOE). The defense work that began during 1943 was narrowly based.
on production of radioisotopes. Since then the primary mission has been expanded to include process development, production engineering, manufacture, surveillance, and evaluation of components for nuclear weapons systems. Frontier technology is the key to work performed at the Mound Facility. They are on the leading edge of ceramic technology.

The Technology Exchange Mission (TEM) was discussed by Dr. Japnell D. Braun. Dr. Braun is the focal point for meeting Mound's responsibilities for the transfer of appropriate technology in the solution of scientific problems. The TEM is the driving force for technology transfer to increase competitiveness of U.S. businesses by making federally funded R&D available for private and public sector use.

Mound operates its own standards laboratory equipped with the latest optical, electronic, pneumatic, and mechanical gauging devices. Rigorously defined length, mass, time and electrical standards are maintained to measure, calibrate, and certify components, processes, and instrumentation used in production and quality control. Most aspects of dimensional, physical and electronic measurements are made on equipment specially designed for the ultimate in accuracy.

There were four outstanding technical presentations. James Fisher with his "Laser Height Gage" presentation showed the benefits of using the laserized height gage to reduce the calibration time and improve precision in the calibration of micrometer height gages. Richard Shaffer's "Standards Lab Automation" presentation focused on the productivity increases which are allowing them to meet the demands of an increased workload with no increase in manpower while maintaining or increasing calibration accuracy. The "Process Measurement Assurance Program" presentation by Jerry Everhart used statistical process control methods to determine the uncertainty in the product and provide a certifiable product. The new standards building facility project that is being proposed for FY 94 was described by Bob Mielke. The proposed facility of 42,100 square feet will consolidate the Mound's standards laboratories into one ultramodern facility.

A very informative and well organized tour of Mound Standards Lab capped off the meeting and made it an outstanding memorable day. Again, I would like to express a note of appreciation on behalf of NCSL, Region 5, to Monsanto Research Corporation, Mound Facility, for hosting the Sectional meeting and especially Dick Shaffer and everyone involved who worked so hard to make it a success.

The Spring meeting will be a joint Northern Ohio/Southern Ohio-Kentucky Section, Region 5 meeting at Battelle Memorial Institute, Columbus, Ohio on 10 March 1988.

ATTENDEES

William G. Roberts  Allison Transmissions
James C. Schuerman  Allison Transmissions

Kenneth B. Tennesen  Allison Transmissions
William Stegmuller  Cincinnati Milacron
William Sears, Jr.  Cincinnati Milacron
Charles E. Butts  Allison Gas Turbine Div.
James H. Johnston  Allison Gas Turbine Div.
Michael D. Patrick  Diconix, Inc.
Donald H. Rahn  Rahn Granite Surface Plate Co.
Charles D. Rahn  Rahn Granite Surface Plate Co.
Wally Horton  MECCA
Clyde E. Moss  Clyde E. Moss Company
Chuck Evans  Yellow Springs Instrument Co.
Philip Metz  P.O. Box 279
David Diff  Eli Lilly & Company
William Scott  Eli Lilly & Company
Norman Bowen  Eli Lilly & Company
Mike Barnes  I & C Sales
Al Beason  John Fluke Mfg. Co., Inc.
Frank Bishop  GTE South
Michael Jacoby  GTE South
James E. Brown  Consumers Power Company
Amos "Max" Green  Technology Applications, Inc.
Larry Peters  Technology Applications, Inc.
Michael Muller  Hattinger Baldwin Measurements
Richard L. Shaffer  Monsanto Res. Corp. Mound
Robert L. Mielke  Monsanto Res. Corp. Mound
Jerry L. Everhart  Monsanto Res. Corp. Mound
George Clarren  Monsanto Res. Corp. Mound
Art J. Wright  Monsanto Res. Corp. Mound
James W. Fisher  Monsanto Res. Corp. Mound
Lois V. Collins  Monsanto Res. Corp. Mound
Ernestine J. Stevenson  Monsanto Res. Corp. Mound
Japnell D. Braun  Monsanto Res. Corp. Mound
Richard J. Huss  Monsanto Res. Corp. Mound
Larry Baird  Monsanto Res. Corp. Mound
Robert W. Crick  Monsanto Res. Corp. Mound

Region 5 members were treated to an informative tour of the Monsanto Mound Standards Lab during their January 28th meeting.
The meeting was opened with coffee and welcoming remarks from Gould's Member Delegate Joe Katoch; it was then turned over to Anne Zucker, the Section Coordinator, who conducted the business portion of the meeting. After highlighting the National Conference, she addressed issues and events of importance to the membership of this Region.

A joint Section meeting is planned for Thursday March 10, 1988, hosted by Battelle Memorial Institute, Columbus, Ohio. Watch for details!

We would like to plan a Section Meeting for Northern Ohio/Mich. Area in the Fall of '88. In early November the weather does not hamper travel. Plus with the National Conference concluding, a great opportunity is presented to get the lowdown first hand if you could not make the conference.

A budgetary note for Labs involved in Dimensional Measurements, comments were made that Temperature Monitoring may be required not only at the upper level, but also at the four corners and at the bench level. This may require the expenditure of capital funds to meet the new requirements, if and when they go into effect.

Volkswagen of America is looking into the feasibility of doing outside calibrations on a fee basis. This would provide another source that we could use for reduction of workload, or to reduce equipment travel distance for a remote service function.

Congratulations were extended to Dave Duff on his election to Director. MKS Instruments, Inc. of Andover, MA (Frank Uttaro (617) 272-9255 x501) will initiate a Vacuum Map around the first of the year.

Philip C. Alderton, Marketing Manager, INSTRULAB INC. Dayton, Ohio presented a paper entitled Accurate Temperature Measurements Made Easier. This paper reviewed the techniques from past to the present, with the usage of today's technology, in the application of PRT's. It covered devices from the manually balanced, 4-wire resistance bridge, Mueller Bridge, AC Bridge, Potentiometric Method, to Automatic Bridges, with direct readout of resistance or temperature. The advantages/disadvantages of each type were covered as is pointed out in the paper.

Following lunch a plant tour of GOULD RSD was guided by Joe Katoch, the host, covering the entire manufacturing process, from Incoming Inspection of material to the final inspection of a finished product. This included stops in the Sheet Metal Shop, Machine Shop, Paint Shop, Photo Lab, Metrology Lab, Assembly, and Final Inspection Areas.

The Voltage Map Plan for the Cleveland area is alive and progressing, with the details being addressed and formulated into a workable plan.

The电压图计划的克利夫兰地区是活的且在进步，详情正在被讨论和制定，最终形成一个可操作的计划。
The attendance of our last regular scheduled meeting was fifty-eight. By category, there were thirty-four representing a test equipment (TE) user; thirteen from TE manufacturers; and eleven from either an independent calibration/report support company, a rental/leasing company, or an education activity; thirty were dues paying NCSL members and twenty-eight were non-members.

**NCSL ACTIVITY/SUBJECTS COVERED**

* Test Equipment Management Forum (EMF) Activities: Comments by Ron Groom of AT&T who attended the February, 1987 meeting.
* Texas A&M Training Meeting by Dr. Robert Benson.
* The July Annual Conference in Denver.
* The Petro-Chemical Measurement Society Organization by Rick Rushing.
* NCSL Members Delegates Documentation; some NCSL members apparently did not receive new RP’s. If a member did not receive RP#6 and #7 (or others), call or write the secretariat’s office in Boulder (Ken Armstrong) at (303) 665-3334.

**DISCUSSION TOPICS COVERED**

Measuring and Test Equipment Calibration and Measurement Laboratory accreditation and personnel licensing.

An entertaining satire with costume was presented starring Jim Smisek as Calvin I. Bratton. This one act/actor play demonstrated the situation which Jim perceives from his preparation activities performed prior to the meeting. His unique presentation on the subject was well done, kept most people’s attention, and stimulated thought and discussion. An attachment summarizes his activities. Conclusion: The subject is volatile and worthy of a second session at which an NBS “interested party” should be present (perhaps Harvey Berger).

Jim Smisek, Testech, Inc. (214) 644-5010

**Status and Results of the Central Section Pilot Round-Robin (MCIA) on RF/Microwave VSWR and Insertion Loss and Proposed MCIA on Lightwave Power Fiber.**

Participants in attendance expressed their opinions and discussed constructively.

—Chris Hancock, Weinschel Engineering (301) 921-3434
—Clyde Orrison, Texas Instruments (214) 995-5031
—Earl Murphy, General Dynamics, Ft. Worth (817) 777-8127

**NCSL; Benefits, Desires, Etc.**

The 1985 Benefits Survey was repeated at the meeting and discussions were promoted on the Newsletter, officer elections, sectionalization, PR, region re-definition, documentation (RP’s and Guides), quality audits, membership, emphasis direction, section location, meeting structure/content, organization name, and re-name, etc. The Newsletter survey forms that were distributed and completed at the meeting were mailed to J. Minck. The results follow this report and show apparent changes in opinion from 1985 to 1987. Conclusion: No major complaints with support and emphasis desired for “good” section meetings (“good” defined as diversified subject meetings of current interest to attendees, discussion topic format with leader and guest speaker). Other comments of note: many thought that the training aids library was obsolete and should be eliminated; why take the time to vote, etc. when there is little or no choice.

**Troubleshooting/Repair of PCB/Modules with Surface Mounted Components and Calibration Report Forms Content and Format.**

Both Don McKenzie of Tektronix and George Brush of Hewlett-Packard were not able to attend (without prior notice), so the sessions scheduled on Troubleshooting/Repair of PCB/Modules with Surface Mounted Components and Calibration Report Forms Content and Format were not held.

**GENERAL**

**Communications – Terms and Definitions (T&D)**

Throughout the day, especially in the accreditation and benefits sessions, the subject of communications emerged. Most of us agreed that in any measuring and test equipment (M & TE) groups’ activities encountered, whether inter or intra company, one normally spends the first two hours to two days getting on the same wavelength. The prerequisite to accrediting, auditing, etc., is validated two-way communication. A suggestion was made to evaluate setting up a possible full day session on M & TE (metrology) T&D’s with a special invitation to have at least regional DECAS,
Reports from the Regions

FAS, and BELLCORE auditing management/representatives in attendance. Preliminary contacts were made with the three organizations and there was interest. However, NCSL Central Section people assisting me in the meeting plans, myself, and the agencies did not find/make the time to set up the "workshop" with a constructive environment and attendance. However, it needs to be done some other time.

Maybe a sign-of-the-times or an omen . . . Doug McCullough of BELLCORE won the Fluke thermometer attendee door prize. Congratulations. We thank you for your attendance, membership, and constructive comments.

Two special thank you's - one to John Fluke Mfg. Co. and host Johnnie Winters for the arrangements, use of their facilities, breaks, refreshments, luncheon, and door prize. We appreciate our host companies. Secondly, to Weinschel Engineering of Gaithersburg and Chris Hancock for traveling to and participating in our meeting for the MCIA projects.

ATTENDEES

Jim Blue
J. L. Winters
J. B. Bebemeyer
Jerry L. Price
Cathy Lowes
Ron Groom
Luke Smith
Ron Groom
Robert Benson
R. F. Mooney
Lee Romine
Bill Grindle
Ronnie Eubanks
Jerry Tidwell
Howard R. Adams
Steve Carson
John Gualltag
Ralph Tillery
Jeffrey St. Amour
Robert Rushing
Harry Friedrich
Vergel F. Burress
Jim Bailey
Kenneth Moore
Luis Diaz
Earl E. Murphy
Lorraine Hess
Harvey Evans
Mack Covey
Clyde Orrison
Jim Smisek
Cliff Snellings
Doug McCullough

Tektronix
Fluke
Xerox
Rockwell
AT&T
E-Systems Greenville
Texas A&M University
American Airlines
American Airlines
Fluke
Otis Engineering
General Dynamics
Cal Labs
USIR
Tellabs
Tellabs
Tellabs
Rickland
Certified Test.
Tucker Electronics
Matrology Specialists
TCMC (Thomson Components)
LTV Aircraft Products
General Dynamics
3M Co.
Scientific Devices
Rockwell Int'L
Texas Inst. Inc.
Testech Inc.
Texas Instruments
Bell Communications

Bob Roberts
G. B. Norman
Ron Glover
Max Maxin
David Schneider
Earl Silvers
Jim McGarg
Tommy Weaver
Moe Kennedy
Jim Musgrove
Ted Taylor
Jim Scriver
Craig Leong
Stan Greych
Chuck Cox
John Scott
Walt Carolus
Richard Gary
Steve Phelps
Bob Willett
Bob Ellis
Ed Yrisarri
Carl Geller
Ken Horne
Grace Girouard

Xerox (Retired)
Boeing Electronics, Inc.
Siemens Medical Sys.
Hewlett-Packard
Lockheed Austin Div.
J&S Laboratories
UPA Tech
Tracor Aerospace
AT&C
Motorola
Motorola
Hewlett-Packard
Tucker Elec.
Data Mktg Assoc.
Braniff
E-Systems
Motorola
Testech
ElPax, PA
Rockwell
Austron
Ball Efratou Div.
Scientific Devices
KS Specialties
Honeywell

DFW NCSL Section Meeting
I. NCSL ELEMENT BENEFITS RANKING FOR REGION 6 CENTRAL SECTION – APRIL, 1987

Benefit score is calculated by adding all ratings and dividing by the total number of responses. A rating of High (H) is worth 3 points, Medium (M) is worth 2 points, and Low (L) is worth 1 point.

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Composite rating is determined by weighting the responses, adding the score and dividing by the total number of responses. A response of valuable (1) is worth 5 points, a response of the next valuable (2) is worth 4 points and so forth through third (3), 3 points, fourth (4), 2 points, and fifth (5), 1 point.
III. COMMENTS ON THE NCSL BENEFITS SURVEY

The following is a collection of comments on the topics discussed at the April 8, 1987 Region 6 Central Section NCSL meeting that was held at the John Fluke facilities.

A. PERSONAL CONTACTS
   * The main discussion here was focused on the directory. Some maintained "it is the most important book in our lab."
   * The directory has general approval.

B. MODIFY THE NCSL CHARTER TO ALLOW PRIVATE PEOPLE TO BECOME MEMBERS.
   * Concerns were voiced that a member might have to leave the membership when retiring from their sponsor organization.
   * The issue remained divided, the nays were concerned about diluting the membership with persons not directly concerned with standards labs.

C. INCREASE THE PUBLIC AWARENESS OF METROLOGY
   * The NCSL has put together an exhibition booth, available for trade shows or similar gatherings.
   * Should the membership base be widened by recruiting members from every measurement field?
   * Members should encourage non-members to attend sectional meetings and related events.
   * If all the above fails to correct the problem a Heathkit weather station should be considered.

D. MAPS
   * There was a general disapproval from our region, but it was pointed out that MAPS could be used when users are in geographical proximity, with active NBS participation.

E.&F. SOFTWARE EXCHANGE AND TRAINING AIDS
   * Outdated and limited formats but it does see some use.
   * The bulletin board service should be upgraded or abolished.
   * Create one agency called "Information Services", and charge a user's fee to maintain and/or increase services.
   * There are a wide variety of sources of material available from within the membership.
   * Allow use of materials by non-members. (i.e. as training aids for auditors, etc.)

G. NEWSLETTER
   * Arrives late, but an improvement in the NBS section has been noted.
   * Improvements in the Newsletter have made it more beneficial.
   * A "Dear Abby" column for metrology issues or questions was proposed.
   * It was pointed out that the Newsletter is short of staff.
   * Reduce the editorial and business contents.

H. DOCUMENTS
   * It was noted that most available documents are outdated and need to be upgraded or replaces.
   * The progress of the RP-3 rewrite was discussed.

I. METROLOGY CAREERS LISTINGS
   * One member indicated that they had used the listing in the Newsletter on at least one occasion.
   * Suggested improvements included expanding the listing to all levels of metrology, and having some regional representation.

J. PARTICIPATION IN COMMITTEES, SURVEYS, ETC.
   * Discussion on this subject concerned MIL STD 45662, it appears everyone has an opinion on this subject and the differing ways it affects their organization.
   * Possible topic for upcoming meeting.

By: Jeffrey St. Amour
Tellabs
601 Jeffrey Way
Round Rock, Texas 78664
(512) 255-1156

MEASUREMENT AND CALIBRATION LABORATORY ACCREDITATION; REPORT ON APRIL 8, 1987 NCSL REGION 6 CENTRAL SECTION MEETING SESSION DISCUSSION AND PREPARATION

The following is a synopsis of the research completed as an effort for my NCSL meeting session on calibration and measurement laboratory accreditation; personnel licensing.

I was first curious as to how many licensed and/or accredited professionals in industries much like myself were knowledgeable of standards and calibration lab "certification". I polled 100 people in approximately 80 different companies and found that 96 of the 100 assumed that since the calibrated instruments they use are calibrated to NBS traceable standards, that the calibration lab providing the calibration service is accredited by the NBS and the people performing the work hold a certification or license of some sort. It became apparent to me that either the Calibration and Standards Labs have done an excellent job of misleading people or those licensed and certified professionals using the calibrated instruments have made some ignorant assumptions. It is my opinion that the latter is true. An industry awareness caused by a legal suit or simply word of mouth could cause extensive pressure at a federal level to implement an accreditation program.

I then surveyed 18 calibration and calibration standards labs. No two labs follow the same practices of operation, including those qualified under DOD standards. Those doing DOD standards calibration were at least close. Where is the standardization in standards labs? I was pleased to find that
most of the lab personnel have had precision measurement equipment laboratory (PMEL) training, but very few, although, have even an associates degree in a science study background. I spoke with John Lock and Pete Unger of the American Association of Lab Accreditations and confirmed most of my findings with the data they have collected. I also spoke with Harvey Berger who is the manager of the National Voluntary Lab Accreditation program at NBS. Harvey expressed a real concern for the lab accreditation problem and seemed very willing to work with NCSL in an effort to establish a program suitable for all calibration and standards labs.

I then began to understand the legal ramifications of non-accreditation should a suit arise. I visited with two law professors at AMU in Dallas. They were even under the assumption that calibration labs were accredited by some federal agency. They stated that without some legal accreditation, the professional credibility would be very hard to establish based on character witness testimony and lab investigation. I called the NBS and told them I wished to have my cal lab surveyed and a legal opinion presented at a legal hearing. I was informed that the NBS did not provide this type of service. This began to make me wonder, if I was being sued, who could I get as a character witness, a customer? Another calibration lab manager? Who?

I finally came to the conclusion that, as is other professions regulated and protected, measuring and test equipment standards and calibration (metrology) laboratory organizations and work output should be also. Through moderate regulation should come standardization. A set of operating guidelines should first be established and adopted. It works well with other professions. If the members of the NCSL do not establish some type of accreditation program themselves, then some federal agency may for you and may so to your disliking. This is the age of the lawsuit and accreditation may be a way of CVA (cover your behind).

I hope everyone enjoyed this presentation. I had fun doing it.

Thanks, Jim Smisek
Testech, Inc.
1909 N. Greenville Ave.
Suite 103
Richardson, Texas 75081
(214) 644-5010

Oct. 15, 1987
Metronix Inc.
Guest Quarters Hotel
Austin, Texas
Randy Wear
South Texas Section
Coordinator, Region 6
Reports from the Regions

Antonio areas; therefore I will continue meetings in those areas. The following are some suggestions on ways to improve meeting attendance:

Have after hour committee meetings which will consist of three separate committees: Austin, San Antonio and Houston. A representative of those committees would then attend the Dallas regional meetings to represent their respective committee.

Continue to have only Dallas region meetings and expect everyone interested to attend.

Have section meetings in the evening vs working hours and hold three per year – one in Austin, one in San Antonio and one in Houston.

* I hope to have discussion leaders in our next meeting to address the Mil-Std 45662 interpretation issues regarding compliance and audits. At present Johnny Winters (Fluke Dallas Service Center Manager) and Don McKenzie or Ron Sutton (Techtronix Service Center Managers) will tentatively lead a discussion on the effects and interpretation of 45662 on their operations.

* Tentatively Kent Crow will discuss compliance with NRC 10CFR50, 20 and 21 and the effects on operations at the South Texas Nuclear Project.

* In the meetings to follow I would like to ask that an arrangement be made to get an auditor, preferably a DCAS auditor, to discuss their interpretations of Mil-Std 45662. The persons assigned to work on this are as follows:

Jim Patterson, SWRI
Wannie McPeters, Barrios Technology

Also I plan in future meetings to have discussion leaders from the commercial calibration labs such as Cal Labs Inc., Metronix Inc., Oscilloscope Sys. and Rothe to discuss the effects of standards and specifications on their operations and the various audit interpretations.

Any inputs or constructive criticism is welcome.

ATTENDEES

Bob Trevino
Cliff Bettinger
Dathan Copeland
Howard Adams
James Shehan
Tom Seallorn
Ken Reeves
Jim Patterson
Mark Thornton

Texas Instruments
Texas Instruments
Hewlett-Packard
Cal Labs
Datapoint Corp.
"Self"
Rothe Development
Southwest Research
Mensor Corp.

Dan Contreras
Don McKenzie
Ron Sutton
Tim Moonan
Jim Good
Randy Wear
Terry Bissell
Sam Rivera
Ralph Tillery
Dick Bigelow
Dave Greenburg

Mensor Corp.
Tektronix
Tektronix
Tektronix
Metronix
Motorola
Fluke
Scientific Devices
Motorola
Metronix
Metronix

Guest Quarters Hotel was the site of Region 6 meeting hosted by Metronix, Inc.

**********

Feb. 4, 1988
Letter to Region 8
NCSL Delegates
Rolf Schumacher
Coordinator, Region 8

As indicated during our Los Angeles Section meeting on November 4, 1988, I have weighed a splitting of the Los Angeles Section and discussed it with some key NCSL representatives of this area, including past and possibly future L.A. Section representatives. As a result, the existing Los Angeles Section will be divided into a Northwestern Section, the "Los Angeles/Valley Section", and a Southeastern Section, the "Los Angeles/Orange County Section". Since the great majority of the Los Angeles Section are located in Los Angeles County, the Los Angeles name should be retained for the successor sections.

Attendance at the Los Angeles Section meetings has been consistently so high that the split appears desirable so that the meetings can be brought closer to the membership, both existing and potential, and simultaneously move the meeting locale to a site where the majority of the attendees can travel.
Reports from the Regions

in the direction opposite to the rush-hour traffic patterns. The agonies of driving to Los Angeles during rush-hour traffic have been of continuous concern to us for over a decade and have probably prevented many member delegates or potential new member representatives, especially from the Santa Barbara and Ventura counties, Oxnard and Vandenburg Air Force Base areas, from attending our meetings. Even our friends from Kern County, Edwards Air Force Base, Lancaster, and China Lake, will have a much easier time to attend one of our section meetings by avoiding travel through Los Angeles City. With this split, we can expect greater overall participation and possibly increased membership.

I am happy to report that Dean Brungart, a persistent advocate of resolving the travel problem, has again volunteered to head a Region 8 Section, this time the new "Los Angeles/Valley" Section. I trust everybody knows Dean. Likewise, Ken Landis, Hughes Aircraft, Fullerton, has accepted the responsibility of heading the "Los Angeles/Orange County Section".

The first meetings will be on March 2 in Westlake and on March 8 in Anaheim. A joint meeting will be held once again at the Proud Bird restaurant on September 21, 1988, to review the reorganization and to discuss your comments and proposals. At that time, we shall also hold our annual "Feedback to NBS".

A late-arriving photo shows the crowd which attended the Hartwell Keith Roast of Nov. 4. Hartwell, with all these "friends", who needs enemies?

Nov. 4, 1987
Proud Bird Restaurant
Los Angeles, CA
Rolf Schumacher
Region 8 Coordinator

REPORT OF THE LOS ANGELES SECTION MEETING

This is the report of the NCSL Region 8, Los Angeles Section meeting held November 4, 1987, at the Proud Bird Restaurant in Los Angeles. Bob Smith of Ford Aerospace and Communications Corporation, the Los Angeles Section Coordinator, had been appointed NCSL Director, and Dr. "Gene" Watson of TRW had been named Los Angeles Section Coordinator to fill the resulting vacancy. Prior to the meeting, however, Gene left TRW unexpectedly; nevertheless, he continued organizing the meeting and conducting it. The report is based on a report written by Gene.

The meeting was attended by 75 NSCL Member Delegates and guests. Rolf Schumacher opened the meeting at 9:00 a.m. and explained the transition in the office of Section Coordinator, thanked Bob Smith for his exemplary job over the past three years, introduced Gene Watson, and turned the meeting over to Gene.

Following some announcements, Bob Smith gave the Report from the NCSL Board of Directors, covering the salient points of the preceding two board meetings held since the last Los Angeles Section Meeting. Garry Davidson, TRW, NCSL Executive Vice President, announced the results of the election of the new NCSL Board of Directors. Of the sixteen Board members, five are from Region 8.

Revision of MIL-STD-45662 is still under consideration. NCSL has made numerous comments and change proposals to the draft revision circulated earlier, and the proposed changes and associated problems will be discussed at the 1988 Measurement Science Conference.

Splitting the Los Angeles Section is being considered to hold meetings outside Los Angeles City so as to facilitate travel to the meeting sites. Section meetings are well attended so that the resulting two sections may still have sufficient "critical mass" attendance to maintain the high level of discussions and participation. Ensuring sufficient attendance at the meetings of both sections is the main concern.

Following the 9:45 self introduction of all attendees, Hartwell Keith, assisted by Andre Bell, both of TRW, presented a slide show of the nine-months Construction of TRW's New Metrology Laboratories in Redondo Beach. Emphasized were the difficulties in innumerable details in rebuilding all laboratories for a total of five million dollars without interrupting regular laboratory operations. Keith acknowledged many helpful recommendations received from George Rice, Rockwell International, Bob Weber, Lockheed Aircraft, and others, based on their experiences in calibration laboratory construction. Gary Davidson will plan a laboratory tour for Region 8 as a special meeting. Details will be announced later.

A "Surprise Program" followed in honor of Hartwell Keith, past NCSL President and long-time active participant and supporter of Region 8, at the occasion of his approaching retirement. The details of this program were described in the January 1988 issue of the NCSL Newsletter. Special thanks are due to Dean Brungart for accepting the responsibility for
organizing and conducting this special program conceived at the Regional Coordinator's planning meeting with Bob Smith and Gene Watson. Many thanks also to all the past NCSL presidents who attended and mostly also contributed to the program, Pete England, Dave Mitchell, George Rice, and John Van de Houten, besides Dean Brungart. Slides accompanied by often humorous "old stories" were used to celebrate "Keith", as he used and liked to be known. Also on hand were Mary Lee Keith in addition to his faithful right hand at work, Cheryl Welsh, as well as manager, Al Strand, who supported Keith so well during many years that Keith contributed to us so much of his professionalism and experience. Many thanks also to this Keith Support Team for attending this celebration. The "roast" was topped by a champagne toast (financed from Region 8's surplus) before the luncheon. It was a great and obviously moving experience for most of the attendees.

After lunch, Bob Smith gave an overview of the NCSL Committee Structure and explained the missions of all NCSL committees. Anybody interested in the work of one or more of these committees and willing to contribute to their work is urged to contact the committee chair or the Regional Coordinator.

Finally, the session on the Effect of Handling and Transportation Shocks on M&TE, begun during the previous meeting, was completed by your reporter with graphic test results showing shocks and vibrations experienced by various items of M&TE under a multitude of handling and transportation situations. No one number can approach to describe shock; acceleration (in G's) is often mistakenly being used, but shock is the sudden change in acceleration. Hence the rate of change of acceleration as well as the length of time that this change occurs would be more appropriate to quantify shock; such figures are only meaningful in describing shocks over limited ranges, however.

After a general discussion of the various findings, results, and remaining problems of shocks, the meeting was concluded with a "round table" discussion under the title "I have a problem, what's your solution?" This regular session is intended to give the attendees a chance to present some of their special problems in the management and operation of a standards or calibration laboratory and associated activities to determine whether others have experienced similar problems and what effective solutions have been found or may be available.

The meeting was adjourned by Gene Watson at 3:35.

Region 8 wishes to thank Gene for his effort in organizing and conducting this meeting and to wish him well in his future endeavors.
Dean Brungart (center), having turned the roast over to Gary Davidson, listens intensely while Keith is breaking up over Gary's familiar dry humor.

## ATTENDEES

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*Canada Centre for Inland Waters*

**7TH ANNUAL CANADIAN SECTION CONFERENCE – 2 AND 3 DECEMBER 1987**

The 7th Annual Canadian Section conference was hosted by the Canada Centre for Inland Waters, National Water
Research Institute, Burlington, Ontario with 80 participants in attendance.

The meeting got underway with an introductory word of welcome from the Canadian Section Coordinator, Mr. Duane Brown.

Special thanks went out to members for their efforts in procuring guest speakers, obtaining door prizes and for organizing workshops. Thanks also went to Quantum Testing and Inspection, Burlington, Ontario and General Motors, London, Ontario for donating coffee and danish.

1988 PLANNING MEETING

Members were invited to attend the Canadian Section Planning Meeting, scheduled for June 25th, 1988 to be hosted by Wally Walberg, Spar Aerospace. Kanata, Ontario. A locale for the 8th Annual Canadian Section Conference, tentatively scheduled for December 8 and 9, 1988, is required. Members were asked to give some thought to hosting the conference or suggesting a place where the conference could be held. A location in the Montreal or Ottawa area was suggested.

HOST

Mr. Brown introduced Les Peer, host of the 7th Annual Canadian Section conference and it was pointed out that this is the second time that the CCTW has hosted the Canadian conference. The first time being in 1985.

Mr. Peer introduced Dr. Ron Allen, A/Director of the NWRI. Dr. Allen expressed delight that the Centre was chosen for the conference and went on to speak a little about the history and role of the Centre.

Mr. Peer also introduced his assistant John Cooper who was very visual in assisting at the conference. Administrative announcements followed.

CANADIAN SECTION ORGANIZATION

The organization chart of the NCSL Canadian Section was shown on the screen and members and their executive positions were introduced by the Canadian Coordinator.

INTERNATIONAL DIRECTOR'S REPORT

Mr. Cameron, International Regional Director, mentioned in his report that NCSL is a non-profit association of laboratories and organizations that maintain or have an interest related to measurement standards and calibration facilities. It was mentioned that the organization has been in operation for over 26 years having received the inspiration for its formation from the National Bureau of Standards, the organization which supported NCSL’s development until it became a self supporting independent body.

It was announced that the NCSL Annual 1988 Conference will be held in Washington, DC August 14-18, the theme being "Competitiveness in the World Market."

Mr. Cameron stated that the International Regional membership exceeds 90 with concentrations in Canada, Europe, the Far East and the oil producing countries. He further stated that currently work is underway to establish a second section within the International Region in Israel.

It was pointed out that sectional conferences are intended to operate on a self supporting financial basis. In 1985 and 1986 equipment and services displays were incorporated in our meeting held in Burlington and Ottawa. A fee was provided to the Canadian Section of NCSL realizing an income of $500. Prior to the arrival of registrants cheques for this meeting the balance was $495. Regular reports of income and expenditures are provided to the NCSL Treasurer to protect our non-profit status.

Mr. Cameron went on to suggest that depending upon the deliberations and recommendations of our educational committee the need for special funding requests for the committee’s future work will likely be enunciated by way of a submission to the Board of Directors before and at the February ’88 meeting.

Benefits of being a member of NCSL were pointed out, an example being the Quarterly Newsletter. The Newsletter’s October issue covered the best paper from the annual conference held in Denver, Co. last July. An Individual Instrument Evaluation Guide* by Jim Ingram of Lockheed Missiles and Space Co., Sunnyvale, CA.

Abstract – Tight budgets and a multitude of products make the selection of test equipment a demanding task for today’s metrology organization. If it were only necessary to look for the least expensive instrument, the task would be fairly simple. However this is not the case; technical specifications, training, repair services, parts support, reliability, company policy, warranty, and documentation are some of the myriad considerations in making the selection. Therefore, it is necessary to approach the selection process in a methodical manner. This paper describes an evaluation system designed as an objective measure of an instrument. Also included are the design requirements of the system as well as methods of application.

The audience was advised that the Laboratory for Basic Standards in NRC’s Division of Physics has selected Dr. Alan Robertson to be the contact person on metrological matters, and as Executive Assistant to the Laboratory’s Director, Dr. Jacques Vanier, he is an excellent source of information and a
It is proposed that NRC and SCC jointly form the Canadian Calibration Network with NRC responsible for technical aspects and SCC responsible for administrative aspects. Fields of accreditation will be introduced gradually and accreditation will be available at three uncertainty levels. NRC would perform calibrations only for accredited laboratories except in special circumstances.

NRC will have the technical assessment responsibilities and SCC will have the assessment responsibilities of the organizational base, physical resources, human resources, and QC procedures.

The estimated cost of accreditation is broken down as follows:

- Overhead: $300,000-$400,00/year
- Assessment: $3000-9000/field/laboratory
- Audit: $2000-$5000/field/laboratory

Dr. Robertson mentioned that it is unlikely that laboratories will be willing to pay the costs and that subsidy will be required. Sources of subsidy: NRC/SCC, federal government, provincial governments and industry associations.

Following Dr. Robertson’s presentation it was pointed out that the DND Recognition Program is only available to commercial laboratories that offer services to the Canadian defence sector but that the Standards Council of Canada accreditation program is available to anyone. A high level of coordination and cooperation exists between DCC, DND, and NRC. The Canadian Calibration Network will not be a rival to DND.

In answer to a query Dr. Robertson replied that the NRCC mandate is to stimulate industrial development.

**Keynote Address**

Following the coffee break Mr. Ross de St. Croix of Alexander Tools introduced the keynote speaker, David Genest, Marketing Manager, Coordinate Measuring Systems Division, Brown & Sharpe Manufacturing Co., Rhode Island, U.S.A. who gave an in-depth, interesting talk on "The Process Control Robot – New Tool for Flexible Manufacturing". In Mr. Genest’s introductory statement he remarked that quality control is dead – quality assurance is in.

Mr. Genest spoke about a survey which he had conducted in many countries on flexible manufacturing systems/cell and transfer line technologies. The question most frequently asked was: Why do people buy your product?

The answer: automated parts manufacturing system; compact unified controlled manufacturing system; lower labor intensity; smaller batches, ultimately lot sizes of "1"; reduced set-up; reduced scrap and direct feedback.

Mr. Genest stated that the key to Direct Process Feedback (DPF) is an independent in-process gage that must be: linked
to the FMS/Cell Transfer line host; as inflexible as the FMS/Cell or transfer line; fast enough to keep up with parts manufacturer; precise enough to provide feedback to the host or accurate M/T offset corrections; self-sufficient and stable in a wide variety of environments.

The question often asked of Mr. Genes is: "How do you make the product?" and the answer is it is designed like a machine tool by machine tool design engineers to operate in production environments."

Facility Tours

During the lunch break ad hoc tours of the National Water Research Institute were conducted.

During the afternoon workshops were conducted in the auditorium and the seminar room.

Workshops

The Education Committee on Electrical Metrology, conducted by Mrs. Nancy Jackson, of Garrett Manufacturing, Rexdale, Mr. Wally Walberg of Spar Aerospace, Kanta, and Dr. Dennis Coffey of Standards Council of Canada, Ottawa, discussed a proposed survey into industry requirements to be submitted to education institutions. The workshop discussed the Education Committee's approach, direction, and events.

The Education Committee on Mechanical Metrology, conducted by Mr. Mike Minow of General Motors, London and Mr. Ron Wilson of de Havilland Aircraft, Downsview discussed the need for mechanical metrology in education; the committees approach; direction and events leading up to the present.

The "Electronic Test Instrument Laboratory Metrologist" document (designing a curriculum) prepared by committee member Mr. Dave Druham of Transport, Canada, Ottawa was reviewed by workshop attendees, suggestions for change were incorporated and the document provided to the committee chairperson for finalization. (See attachment). The "Generic Metrology" and "Dimensional Metrology" documents prepared by committee member Mr. Ron Wilson were reviewed by workshop attendees, suggestions for change were incorporated and the documents provided to the committee chairperson for finalization (see attachment).

A workshop was conducted by Mr. Dereke Pilcher, Metrology Laboratory Supervisor, Quantum Inspection & Testing Ltd., Burlington on measurement uncertainty as it is related to precision instruments, i.e. micrometers, verniers surface tables, height gauge and optical 3-coordinate measuring systems. Discussions on the relative merits of the measurements taken with the above-mentioned instruments as related to their applications and environment took place.

Another workshop was conducted by Mr. Robert Hagger, Manager, Commercial and International Calibration, John Fluke Manufacturing Co. Inc. USA on The Development of Alternative Standards for DC and LF Measurements and Calibration. Because digital multimeters and the calibrators required to verify their performance have changed greatly in the last few years state-of-the-art specifications for these calibrators have led to the development of high stability, easy to use standards which are suitable alternatives to more established equipment and techniques. The presentation discussed the limitations of traditional standards and described the performance, design and traceability of today's solid state reference.

A workshop on Military Standard Requirements; MIL-STD-45662/AQAP-6 was conducted by a DND and Industry panel consisting of:

Moderator: Russ Winfield, Supervisor, Test Equipment Services, Garrett Manufacturing, Rexdale, Ontario; LCol V. A. (Wally) Reinh, Section Head Quality Engineering Director Quality Assurance Policy & Programs, Department of National Defence, Ottawa, Ontario Sid Thacker, Staff Officer, Quality Management Review, No. 3 Canadian Forces Technical Services Agency, Downsview (Toronto), Ontario Wally Wallberg, Manager, Repair, Overhaul and Calibration, Spar Aerospace, Kanata, Ontario

The panel discussed Quality Assurance, Calibration and Laboratory Standards and the DND Laboratory Recognition Program; differences between MIL-STD-45662 and AQAP 6 were highlighted. Mr. Walberg gave an industrial perspective of the application of AQAP 6.

The attendees were provided with copies of the above-mentioned documents.

ATTITUDE ADJUSTMENT HOUR AND DINNER

An attitude-adjustment hour and a buffet dinner at the host facility followed the workshops. These events provided an excellent opportunity for discussion.

Thursday's activities got underway with a presentation by Nancy Jackson, Chairperson, Education Committee.

Ms. Jackson asked the audience for their commitment to the Education Committee and stated that the role of the committee was established at their first meeting. Their role is: (a) to create an awareness in education institutions and determine a need; (b) by monitoring and evaluating instruction; and (c) by providing ongoing support for metrology education. The committee's objectives are in the three disciplines of dimensional, applied physics and electrical metrology.
Ms. Jackson stated that the next step is accreditation, therefore the committee must develop policies. She went on to speak about a needs survey which the committee is anticipating conducting from which the committee is hoping to influence decision makers at education institutions with the need for them to offer courses for metrologists. The attendees were asked to help create an awareness for metrologists by asking for metrologists when hiring.

Ms. Jackson stated that preliminary inquiries of several companies have established that a needs survey would cost approximately $10,000 depending upon the extent of the survey and that in supplying information for the survey, names of contacts, as well as company name should be provided. It was further stated that approach to education institutions to bring about the insertion of metrological subjects requires a major well orchestrated effort. Ms. Jackson asked for more representation on the committee and said that anyone interested in joining, including representation from the Montreal area, the National Research Council, would be most welcome. The committee meets in January, May/June and at the annual meeting.

During the question period it was established that a portion of the survey cost may be obtained from provincial sources (in Ontario, Ministry of Skills and Development). The International Regional Director will be presenting the topic to the NCSL Board of Directors and seeking financial support beginning with the February meeting.

Dr. Dennis Coffey gave a report on an education committee meeting held during NCSL '87 in Denver, Co. on July 14th, 1987 at which time it was established that Macon Community College in Detroit has a two year control program and that there is two year program in metrology at Butler Community College, Pittsburg, PA.

Dr. Coffey mentioned that there is an Accreditation Board for Education Training in the U.S.

The "Metrology – The Science of Measurement" slide presentation developed by Standards Council of Canada was given at the Denver meeting. Dr. Coffey narrated the slide presentation and requested comments on the written narrative, which had been distributed in advance with the conference agenda. Dr. Coffey "walked through" the script for the second version, designed to mold the attitudes of educators and raise the level of importance of metrology for those in late years of high school/early years community college. The presentation in its present state can be borrowed through Dr. Coffey if anyone is interested.

Posters were made available to attendees of the National Standards System Chart, developed by Standards Council of Canada.

The slide presentation was followed by an audio-visual provided to Dr. Coffey by Butler Community College "A Career For Your future – Metrology".

ROLF SCHUMACHER – ROCKWELL INTERNATIONAL, ANAHEIM, CA

Mr. Cameron introduced the next guest speaker, Mr. Rolf Schumacher, of Rockwell International, Anaheim, California. To start his presentation Mr. Schumacher showed a video tape on operations at Rockwell International depicting what technical employees need to know about the organization's calibration control system and the employees' respective responsibilities.

Following the film Mr. Schumacher gave an interesting, well documented presentation, which gave the group a good insight into what is being done in the field of measurement uncertainties, entitled "A New International Standard on Calibration Systems" and "The Controversy Over the BIPM Recommendations on Uncertainties Keeps Growing".

DR. ANDY DUNN, MEASUREMENTS INTERNATIONAL, PRESCOTT, ONTARIO

Mr. Leckey introduced Dr. Andy Dunn, of Measurements International Limited, Prescott, Ontario.

Dr. Dunn told the audience that a question asked of him recently was "Why do you make a measurement?" The answer he reported is "You make a measurement in order to make a decision".

Dr. Dunn gave an interesting, in depth presentation on "The Statement of Uncertainties – An Alternate View". Dr. Dunn began his talk by stating that there are aspects of published manuscripts which cause grave concern such as:

(a) the apparent refusal by some to consider any terms other than "random" and "systematic" to describe errors and/or uncertainties. It has also been suggested that type A and type B (suggested by BIPM) have become "cast in concrete";

(b) one form of reaction to any change in thinking was that "acceptance of the BIPM recommendations would require costly and confusing conversion"; and (c) another reaction appears to be "this BIPM methodology has the potential to alter our whole approach to the subject of measurement uncertainty if it is ever applied to data outside that obtained in the calibration laboratory".

Dr. Dunn went on to say that these examples of what appear to be intransigent positions on various sides of very complicated and confusing matters which should be amenable to a technical solution, leads one to believe that there is little hope of a resolution at this stage. He questioned that the people involved were even addressing the right question, and
suggested they would do well to go back to the drawing board and start over.

For further information on Dr. Dunn’s talk see attached paper.

**WORKSHOP – LABORATORY ACCREDITATION**

A workshop on laboratory accreditation was conducted by Mr. John Leckey, Hewlett-Packard (Canada) Ltd., Mississauga, and Mr. Gary Hysert, Standards Council of Canada, Ottawa.

Mr. Leckey introduced the workshop, emphasizing that accreditation is open to all calibration laboratories not just those claiming the most accurate capabilities, such as reference standard laboratories. He mentioned some of the benefits of accreditation from the perspective of an accredited laboratory, including those which might not be immediately apparent to prospective applicants.

Mr. Hysert discussed the SCC laboratory accreditation program covering the criteria and requirements for accreditation, the benefits of accreditation and the accreditation process for both testing and calibration laboratories. The process is identical for all laboratories with respect to the verification of compliance with the Council’s generic requirements. The procedure for checking on the package of characterized measurement devices. The results of the applicant’s measurements on these artifacts are used to verify the labs measurement capabilities and uncertainties. Mr. Hysert reviewed post assessment activities such as audits and measurement assurance programs. He discusses program costs and commented on similar national programs in other countries. Mr. Leckey reviewed the presentation of measurement results and commented on the accreditation process from a labs point of view. Many labs are particularly concerned with the length of time it takes to become accredited. He indicated the accreditation process was tremendously valuable to an applicant. By watching the team assess the system, one could identify elements of the operation that require attention or improvement. He considered the accreditation process to be of positive value.

Following the lunch break the SCC video “Lab Bench” describing the laboratory accreditation program was shown.

**CUSTOMS/TARIFF MATTERS**

Mr. Wally Butts of W. J. B. Precision Sales, Cambridge, Ontario and Canadian Section’s Customs Chairperson reported on the current situation and to facilitate the assistance Wally provies to NCSL member organizations, the section will purchase a Handbook of Canadian Customs and Excise Tariffs and provide it to him on long term loan basis.

**WORKSHOP – “APPROVAL” AND “SPECIAL INSPECTION” ELECTRICAL INSTRUMENTS CSA AND ONTARIO HYDRO**

Following Mr. Butt’s update on Customs a workshop chaired by Mr. Mike Nagata, Canadian Standards Association, Rexdale, Ontario took place. The presentation was in three parts: (a) provincial inspection view by Mr. George Fisher of Ontario Hydro: (b) “CSA” and its activities by Mr. Mike Natagaga and Special Acceptance and Inspection Service by Mr. Gerd Galler of Canadian Standards Association, Rexdale.

Mr. George Fisher, spoke on the requirement in the Ontario Electrical Code with amendments and its application to the inspection of electrical instrumentation.

Some questions were posed by Mr. Wally Butts of W. J. B. Precision Sales, Cambridge and Mr. Russ Winfield of Garrett Manufacturing, Rexdale on the requirements to inspect instrumentation at the point of delivery. They countered that a more acceptable procedure would be to have the inspection performed in the instrument manufacturers plant at final test. Ontario Hydro indicated inspections fall under provincial legislation and this requires inspection at set-up, i.e. installation.

Mr. Nagata shared an overview of the Canadian Standard Association – CSA and its standards, certification and testing activities. He stated that CSA is “not for profit” private sector association, founded on 1919 and is Canada’s largest standards writing and certification organization.

Mr. Nagata went on to say that CSA is a national forum encompassing the views and interest of Canadians from all regions and walks of life that serves the public, governments and business in:

- development of standards,
- providing services in certification, testing and inspection and other information related services.

CSA membership is open to any individual, company or organization interested in standards activities.

CSA is a member of the SCC National Standards System and formally accredited by the Standards Council of Canada in the fields of standards writing, — certification and testing in electrical mechanical and photometries and metrology. Mr. Nagata went on to say the SCA’s services to customers include certification, technical information, development testing and pre-certification testing and testing to international standards. Among the many products and services tested and certified are electrical and electronic products; building products and structures; fuel burning and handling equipment; health care products and services; plumbing and plastic products; recreational and occupational health and safety equipment.

A wide range of certification procedures have been developed to serve individual requirements of manufacturer, suppliers and service organizations. Some of the services mentioned are:

“Shared Certification” – customers conduct their own tests using the relevant CSA standards and procedures
and prepare the CSA report for acceptance by CSA. It allows customers to set their own certification time schedules in cooperation with CSA.

"Category Certification" – developed for manufacturers of high tech equipment faced with rapid moving technology and frequent product changes. The program allows the qualified customer to test and evaluate the products as required by the standards, maintaining documentation and apply the CSA mark to the products covered. The CSA representative visits the plant to ensure good quality control is maintained and also to be a resource for interpretation and application of CSA requirements.

"Customer Services" – assist certification customers with their applications or any concerns, process straightforward applications and explain the certification process.

"Technical Information Services" – technical consultation prior to formal application for certification, when in the early stages of developing a new product or product with "state-of-the-art" features not covered by the existing standard.

"Pre-Certification Testing Service" – A testing service to help customers at the design or development stage to determine whether the product, non-certified component, such as a switch or thermostat, or special materials will meet the test criteria of the applicable CSA standard or have critical or long-term tests required for the certification process conducted in advance.

"Electrical Safety Special Acceptance Service" – The program fulfills the special needs identified by the industry and the various provincial authorities having jurisdiction by evaluating products for which CSA certification is not practical because of various reasons. Mr. Nagata advised that Mr. Gerd Galler, of CSA would expand on this.

A video tape entitled "Part of your Life" which illustrates CSA standards, certification and testing activities was shown.

The meeting was adjourned following the final door prize draw. Many thanks to Ross de St. Croix, Alexander Tools and Mike Minow, General Motors for the excellent job they did in coordinating the draw for door prizes, obtaining many valuable prizes and arranging the draw in an efficient manner.

Thanks also go the Mike Minow for donating the NCSL decals. Several attendees provided a $1.00 donation in exchange for a decal – "to aid the Canadian cause".

The tape "NCSL – An Introduction" used to promote membership can be obtained from Marilyn Ross, NCSL Canadian Secretariat, in 1/2" and 3/4" format, (819) 997-3411.

Certificates of appreciation were presented to participants of conference and Marilyn Ross for her excellence in performing Canadian Secretariat functions throughout the year and assistance in planning the 7th annual Canadian Section Meeting.

In accordance with normal practice a complete set of attachments is provided to all Canadian section member organizations whose member delegate was unable to attend. The transportation disruption due to the Air Canada dispute made it impossible for certain member delegates to attend.

February 18, 1988
Wilton Company
Morgan Hill, CA
Paul Chong
Coordinator, Region 7

REGION REPORT

Region 7 met on a sunny February 18th at the Wiltron Company in Morgan Hill, California with 56 individuals representing 30 different organizations. Since I have been keeping records, this has been our best attendance to date. Our hosts were Dr. Peter Lacy and Malcolm Gregory.

The meeting agenda included the NCSL BOD report, an update on the proposed revision to MIL-STD 45662, two special topics and a tour of the excellent Wiltron facilities.

Malcolm Gregory, QA Manager, welcomed us the Wiltron. I also welcomed the attendees and announced the following six new member-companies to Region 7: Argon-systems Inc, Electronic Test Magazine, Hewlett-Packard Product Support Division, Intertyme Metrology Laboratory, NBR Enterprises and Valley Communication Engineering.

At this meeting, we have met the two goals set at the previous meeting for 1988, namely, increase the regional membership by ten percent and to provide an environment to promote more interactions amongst the attendees.

Jim Ingram, Group Leader of Lockheed Missiles and Space Company and NCSL VP-Industrial Technology, gave the BOD report along with highlights of the upcoming 1988 Workshop & Symposium to be held in Washington DC. 70 speakers have already been committed along with a like number of exhibitors. Jim reports that the NCSL member-companies have reached a record 880.

Carl Quinn, President of Simco Electronics and NCSL Laboratory Evaluation Committee Chairman, gave the update to the proposed revision to MIL-STD 45662. Carl was on a discussion panel with Ed Nemeroff of Datron/Wavetek, John
Reports from the Regions

Lee of Telogy and David Mednick, DOD representative on this subject at the recent Measurement Science Conference held at Long Beach, California. Carl's impression, from Mr. David Mednick, was that another review draft would not be necessary. DOD plans to incorporate many of the recommendations made from the NCSL Government Affairs Committee testimony. October, 1988 is the target release date. Revised Handbook 52 is expected to follow shortly there-after.

Dr. Peter Lacy, Chief Scientist, Chairman of the Board for the Wiltron Company and NCSL delegate-member, lead the presentation on "Microwave Network Analyzer Calibration and Uncertainty Analysis" by describing the evolution of vector analyzers to the present day network analyzers which parallels the history of the Wiltron Company. This was followed by other Wiltron staff (Dr. Martin Grace, Director of Research and Development, emphasized accurate gain measurements; Frank Tiernan, Manager of Microwave Customer Service and Computer Information System, stressed accuracy verification; Jim Nash, Cal Lab Supervisor, stressed use of the self generating software and use of the calibration set; and Steve Shmania on training). The Wiltron model 360 network was used as the measurement vehicle in this presentation.

Fred Telewski, Product Development Manager of the John Fluke Manufacturing Company, Everett, Washington, topic was "Precision RF Level Measurements To Submicrovolt Levels." Fred slanted his talk on Fluke's technique for measuring the outputs of their output attenuators for their line of signal generators.

Malcom Gregory and Jim Nash divided our attendees into two groups for the tour of the Wiltron buildings. Judging by the copious note takers, the tour was the high point for some of our attendees. As for myself, I have never viewed a more clean machine shop than the one I saw at Wiltron.

My thanks again to our hosts, Dr. Peter Lacy, Malcom Gregory and their associates for the use of this fine facility, for providing refreshments and the hosted luncheon. A special thanks to the unnamed Wiltron associates who helped with the morning registration, reserved parking signs, tour guides and the many individuals who provided the narratives along the tour guides and the many individuals who provided the narratives along the tour route. My personal thanks to each of the presenters and the attendees for their contributions to this meeting.

ATTENDEES

John Barr          HP (Santa Rosa)
David Buckley      HP (Palo Alto)
Debbie Cabusas     Watkins-Johnson
Tim Carey          HP (Palo Alto)
Paul Chong         ESL Inc.
Joe Corege         HP (Mountain View)
Timothy Cowden     Simco Electronics
F. (Dan) Dancisin  ESL Inc.
Steve Dolcater     Lockheed Missiles and Space Co.
Linda Ferguson     Intel (Santa Clara)
Lloyd Friend       Kaiser Electronics
Warren Glenn       TRW/EPI (San Luis Obispo)
Mega Goehner       Watkins-Johnson
Martin Grace       Wiltron
Malcom Gregory     Wiltron
Robert Harano      IBM
Neil Harrer         Scientific Devices
Ken Harrison       Scientific Devices
Al Hill            IBM
Dave Hopping       HP (Santa Rosa)
Gerry Horkan       HP (Palo Alto)
Jim Ingram         Lockheed Missiles and Space
Rusty Jarzombek    Avantek
Doug Johnson       FMC-Central Engineering Lab
Bob Kaiser         Lockheed Missiles and Space
Jim Kang           General Electric
Phil Kirsh         ESL Inc.
Peter Lacy         Wiltron
William Mauser     Apple Computer
Frank Meyers       Signetics
Jack Milburn       NBR Enterprises
Bill Molenkamp     HP (Palo Alto)
Jim Nash           Wiltron
Pat Nolan           Lockheed Missiles and Space
Brent Palmer       HP (Palo Alto)
Jerry Papenfuss    General Electric
Robert Peck        SE Laboratories
Chuck Perston      Dalmo Victor
Carl Quinn         Simco Electronics
Baham Radjari      Lockheed Missiles and Space
Paul Rohrer        Rohrer Instrument Sales
Gary Ross          Kaiser Electronics
Edwin Sabathia     IBM
Steve Shmania      Wiltron
Jeri Stahlheber    FMC-Ordnance Div.
Alexander Suchy    National-Fairchild
Fred Telewski      Semiconductor
Frank Tiernan       John Fluke Manufacturing
John Tompkins      (Everett, WA)
Bob Weber          Wiltron
William Wexted     Applied Technology
Thomas Whiteley    Lockheed Missiles and Space
Bob Williams       GTE Government Systems
Warren Wilson      Ampex
Mike Zall          Optical Associates
                      Lockheed Missiles and Space
Reports from the Regions

Group - "We are gathered to record the closing of another beautiful day".

Lunch - "The setting arranged by the Wiltron Company made the sharing process that much easier".

Touring Standards Lab - "On tour of Wiltron's testing area".

Touring Testing Area - "Viewing Wiltron's calibration laboratory behind closed doors".
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