

NCSL International
Serving the World of Measurement: Meeting Education and Training Needs of the Future

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Introduction

This white paper has been developed to serve as a discussion piece for NCSLI strategic planning in the area of metrology training and education. We hope to identify and summarize short-term and long-term needs and direction as well as potential strategies to meet metrology training and education needs of today and the future. It has not been possible to track the inputs of the many participants at every session that has been held in 2005 alone, but suffice it to say, that this summary reflects the thoughts and opinions of well over one hundred metrology professionals, most all of whom have expressed the need for a strategically focused effort on ensuring metrology education and training needs of the future. This paper is being presented at the 2005 NCSLI Workshop and Symposium where additional solicitation of ideas and priorities will be requested from all participants through session discussions, kiosks, and informal conversations. Additional input to help prioritize objectives will also be requested through use of the NCSLI Newsletter and website.

We believe that the ideas and concepts presented and summarized here will result in a more efficient strategic organization, provide long-term direction for the NCSLI training & education committees, and aid in developing specific action items for NCSLI committees and stakeholders. We expect that a final version of a Strategic Roadmap will be useful to a number of individuals and organizations who may not be a part of NCSL International but who are stakeholders in the world of measurement.

NCSLI Vision

In 2002, the NCSLI Board of Directors began having discussions led by Terrelle Wilson, then a committee chair in the NCSLI Education Liaison committee, regarding the vision of the organization as related to metrology education and training. In January 2003, Terrelle made a proposal to change the vision to enhance NCSLI's focus on education and training. The Board of Directors voted to change the vision statement and the following statement is the result of the discussions, proposals, and final approved changes.

Promote competitiveness and success of NCSL International Members by improving the quality of products and services through excellence in calibration, testing, and metrology education and training.

¹ Georgia Harris works in the Weights & Measures Division of the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. She is also the current NCSL International (NCSLI) Vice President for Education and Training. The ideas and concepts compiled in this white paper do not necessarily reflect personal opinions of the author, official positions of either NIST or NCSLI, and are compiled from input obtained from many people at multiple workshops, board meetings, NCSLI section meetings, focus group meetings, teleconferences, and e-mail correspondence.

“Education and training” has been a significant component and activity identified in previous strategic planning efforts (such as those led by Don Dalton on “Vision 2000” in the mid-1990s) and in many of the long-range plans that are developed and refined each year by each incoming NCSLI President. In fact, the current President, Harry Moody, identified Education and Training as one of his top level objectives. Dave Agy as President before Harry Moody had similar objectives for Education and Training. Harry has 5 “key initiatives” that he has identified and one is “Education and Training.” From the Presidents Message we can see the following:

“Education and Training -The metrology community is facing a shortage of qualified, trained metrology personnel across the U.S. I have asked Georgia Harris to be the Vice President of Education and Training. One of her charters is to develop and implement a plan to increase the opportunities for NCSLI members to obtain technical training.”

This paper and plan for a strategic roadmap are in response to this charge.

NCSLI Operating Principles (Ground Rules)

Some things to keep in mind from NCSLI’s perspective as this strategic planning develops include the following operating principles:

- NCSLI is a non-profit organization composed of organizations (the Majority) and individual professional members.
- Education and training is a key part of the NCSLI vision. The NCSLI culture fosters collaboration and sharing of technical information among all members and the metrology profession.
- NCSLI may develop education and training opportunities through member-collaboration and committee activities in areas where strategic and technical gaps have been observed and when requested.
- NCSLI training activities are expected to recover related and associated costs. Incidental surpluses may be rolled into scholarships or into educational and training resources and activities.
- Many of the objectives described as strategic activities may require the support of the Board and interaction among more than one committee or organization. Some require the development of new committees.
- NCSLI funding for some key activities will be required, but additional creative sources of funds should be considered and sought.

Gathering Information

NCSLI Survey on E&T

Terrelle Wilson was appointed as the VP for Education & Training for 2003-2004. As a part of his activities, he began an education and training survey to gather insight regarding the education and training perspectives and needs among the metrology community. Additional work is needed to filter and summarize the information in the survey. An initial review of the database found a number of people who had expressed interest in staying involved in NCSLI education and training activities; follow-up communications were made.

January 2005 Workshops

Workshops were held as a “160 Committee” meeting at the 2005 Measurement Science Conference and at the January 2005 Board of Directors Meeting. A summary of these workshop notes are attached as Appendix A.

NCSLI Section Meetings

Input to this plan has also been collected at NCSLI section meetings. In several cases, the draft strategic challenges were shared to get a sense of our member needs and priorities. NCSLI Education and Training Activities have been presented in Puerto Rico, Orlando, Atlanta, Maryland, Los Angeles, Canada and other sections by the time this paper is presented.

2005 Workshop & Symposium

Three sessions have been developed at this 2005 Conference that focus on Education and Training. Two were developed as a part of NCSLI committee activities and one as a part of the American Society for Quality, Measurement Standards Division. There is overlapping involvement of the people in both organizations in some areas of interest.

NCSLI Website Forum

The NCSLI website forum has been used to post information and ideas and to solicit additional input – with very poor success. The Forum in this case has gotten surprisingly little use and has provided little value added.

Analyzing & Synthesizing Information

Information and ideas from the various meetings, workshops, and forums was analyzed, summarized, and synthesized into draft “drivers” and “strategic challenges.” These draft documents were reviewed in a teleconference meeting in April 2005 and in a focus group meeting held at NIST in April 2005. Additional reviews of this material and information continues to take place after the deadline for paper submissions. For example, it was discussed at the April Board of Director’s meeting, at section meetings in CA and MD, and with individual member organizations. Our high-level objective at this stage has been to ensure completeness and that we are taking the needs of our various members into consideration as we draft future directions.

Proposed Strategic Challenges

Detailed information that correlates with the drivers and objectives presented here is attached as Appendix B. This is a summarized version from a high-level perspective.

Identified Systemic Critical Drivers (as of April 2005)

The following statements have been filtered from the input received as of April 2005. They form the drivers and foundation for why many of the objectives have been selected and why individual goals will be set. We believe that they identify key problems that must be addressed to ensure that the education and training needs of the future are met.

Outreach

- The typical policy and decision makers, managers, and consumers have no understanding of metrology, quality, or the standards infrastructure or of its value and indispensability.
- There is no central “voice” for the measurement community.

Human Resources

- There is a critical ongoing loss of metrology expertise (in the U.S).
- The changing demographics in science, technology, and engineering, (aging staff, retirements, loss of military personnel, lack of interest in these careers, smaller next generation, higher pay and glamour in other fields) along with the lack of a clear career path in metrology, is causing a shortage of qualified staff that will worsen.
- There is a lack of educational depth and capacity in the less experienced personnel at all levels.
- The current certification system (CCT) evaluates knowledge-based proficiency but not demonstrated competency.

Education

- There are a limited number of degree programs in “metrology” that support the educational needs of the measurement industry.
- More integration of metrology courses in other curricula is needed.
- There is inadequate collaboration and flexibility among providing institutions.
- There have been no recent curriculum assessments to ensure that the programs are meeting current needs; or plans for improvements and enhancements to meet future needs.
- There is no documented history of attempts at developing metrology programs.

Training

- There has been no systematic assessment of what training is available and what training is needed, although the perception is that there are gaps and inadequacies (for both instruction and instructors). There has been no needs analysis; no gap analysis.
- There is no system in place for assessing the quality or levels of technology, client needs, and instruction that are available.
- There is no central resource for information on metrology training.

Infrastructure

- There is no system to capture measurement knowledge and information and ensure its availability as needed.
- There is no system that links upcoming technology trends with methods for ensuring that people are trained to support it.
- There has not been a coordinated forum for ensuring that the right people and resources are brought together to ensure that metrology staffing needs are met at all levels.
- There has not been a focused effort to ensure that funding for metrology education and training are available to meet the needs.

Strategic Challenges - Descriptions

These 11 possible strategic challenges have been synthesized from the drivers and from input received as of April 2005.

1. *Metrology & Standards Outreach.* Ensure awareness of metrology, measurement sciences, and needs for calibration and standards in such a way that it is readily recognized by organizational managers and the general public.
2. *Career Opportunities.* Ensure that clear career paths are identified and communicated as widely as possible and to ensure that labor statistics are tracked and available.
3. *Personnel Qualification.* Ensure that appropriate methods or systems are in place to provide appropriate recognition and credibility for the metrology professions.
4. *Metrology Education.* Provide multiple forums for metrology educators to interact, and to encourage sharing of ideas and resources, and to help ensure that stakeholder educational needs are met.
5. *Training Resources.* Ensure that information and resources on metrology education and training are widely available and to ensure a high level of awareness.
6. *Training Opportunities.* Ensure development, implementation, and recognition of real-time (fast-response) metrology training.
7. *Training Assessment & Certification.* Develop and provide an infrastructure for assessment (and certification) of metrology training courses.
8. *Knowledge Management.* Ensure that critical infrastructure needs for ongoing knowledge management are in place and flexible enough to capture and widely disseminate metrology expertise.
9. *Technology Trend Analysis.* Ensure identification of potential education and training needs in support of measurements and standards needed for new technology infrastructures.
10. *Collaboration.* Ensure that the entire metrology community and stakeholders work together to gain synergy in achieving our goals.
11. *Funding.* Ensure that adequate resources are available to support metrology education and training.

Draft Model

The following model has been developed in an effort to communicate a high-level picture of the areas of involvement and impact related to metrology education and training. Various stakeholders will likely have differing perspectives and priorities based on their views of each category and their mission and focus. For example, training providers may have a different view of formal metrology educational programs and will have different priorities with respect to the time, effort, and resources that should be allocated. Organizations such as the Measurement Science Conference (MSC) or the American Society for Quality (ASQ) who have individuals, divisions, and committees that work closely together in multiple organizations may also have differing perspectives and priorities depending on the organization they represent.

1. Metrology & Standards Outreach		
<i>Human Resources</i>	<i>Education</i>	<i>Training</i>
2. Career Paths 3. Personnel Qualifications	4. Formal Programs	5. Training Resources 6. Training Opportunities (Events) 7. Training Assessment
<i>Infrastructure</i>	8. Knowledge Management	
	9. Technology Trend Analysis	
	10. Collaboration	
	11. Funding	

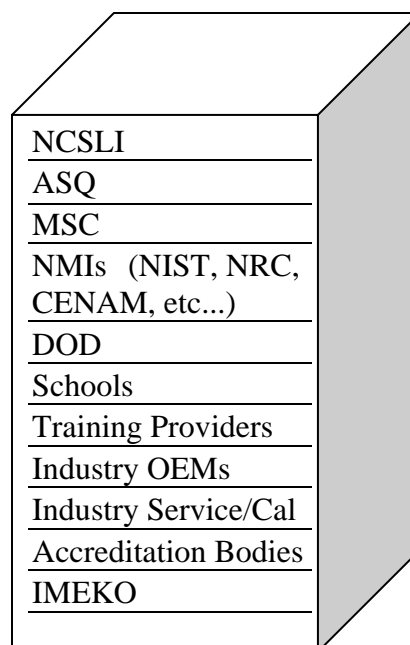
For example, NCSLI has activities and interests in all of these categories to varying degrees and levels of success. MSC primarily focuses on the meeting needs in the Training category as a part of its annual conference but also has scholarships that support individuals seeking metrology education. ASQ (at a high level) primarily focuses on the Human Resources category with the Certified Calibration Technician program and with efforts to update the Standard Occupational Classification System. However, individuals may participate in all three organizations (NCSLI, MSC, and ASQ) and often have broad-based interests across the entire spectrum.

In addition to overlapping needs with organizations outside of NCSLI, there are some committees within NCSLI that may have overlapping needs with education and training objectives. Synergy can be gained by working more closely together. For example, Marketing may work to ensure Outreach. The Measurement Requirements Committees may work to help identify Technology Trends that will impact education and training needs of the future. Benchmarking may gather data that can be used in communicating statistics related to Career Paths. In fact, goals related to some of these objectives may already be underway, but simply not coordinated at a high enough level to be most effective.

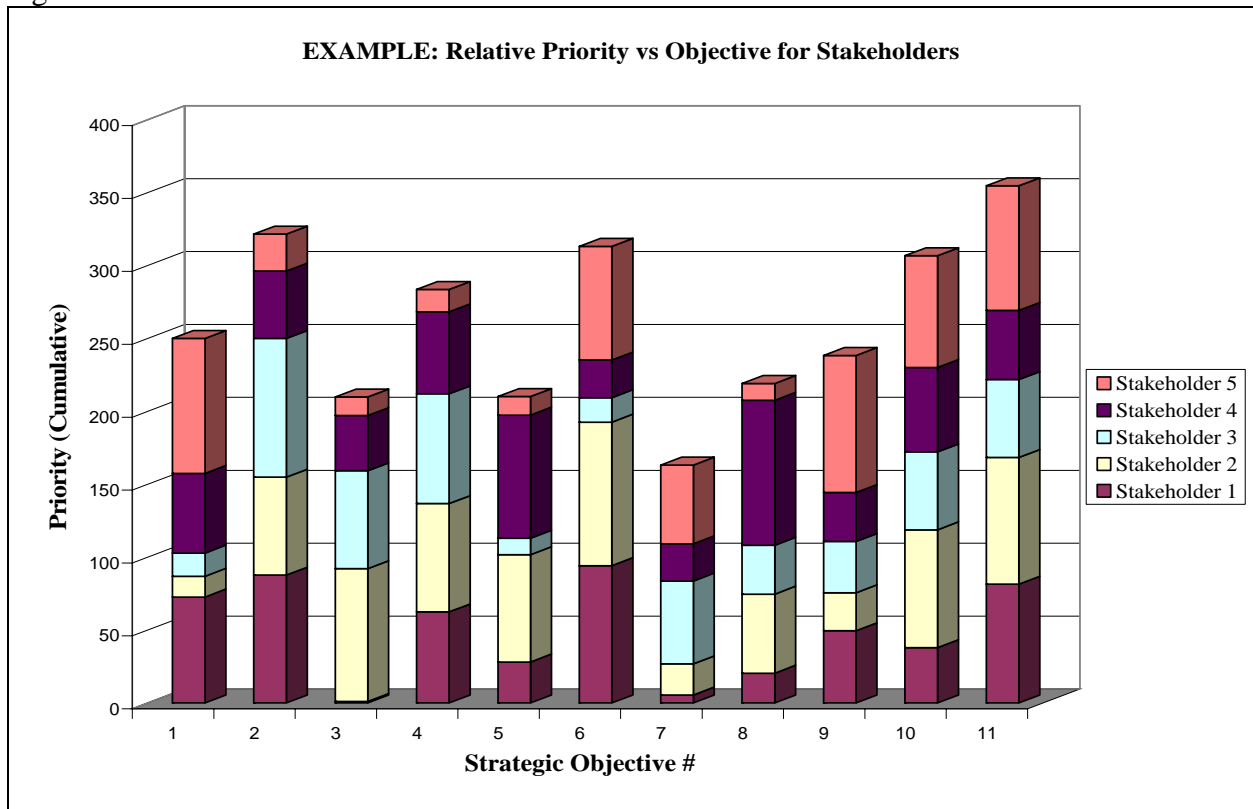
Possible Assessments

If we place the 11 categories as the top level on a 3-dimensional box, the stakeholders can be represented down the face of the box as shown in the next figure.

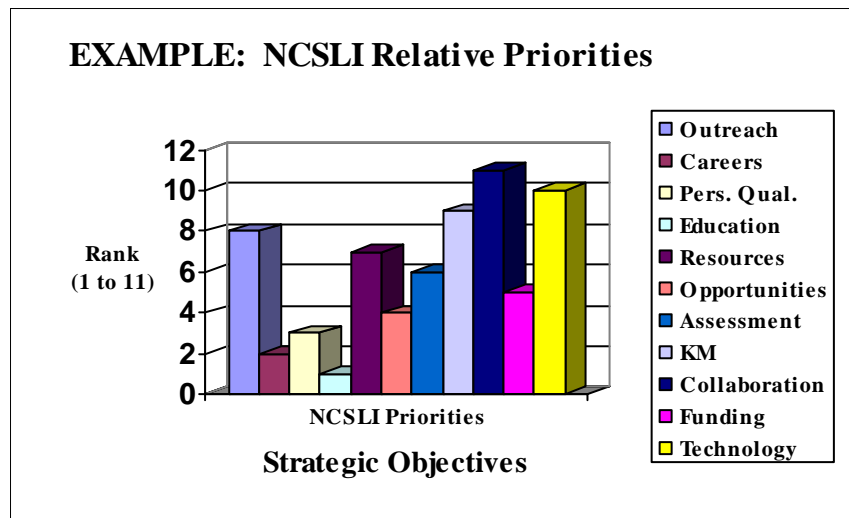
In assessing the values and level of priorities for each organization, we can gather input to summarize it graphically down the other axis. For example, if we ask each organization to divide its priorities and rank each category from 1 to 11, we might create a summary graph for each group and for the entire roadmap as a whole.



This fictitious graph shows the top cumulative strategic categories (with numbers potentially totaling 500 from 5 stakeholders). Because the values were randomly generated, they are meaningless. However, if this was an accurate representation of the top priorities among 5 key stakeholders, the two top areas of priority would be numbers 11 and 2. In addition, each stakeholder will continue to pursue their unique goals and objectives in each of these categories. Where partnering and collaboration and sharing of resources can be done, each stakeholder could have an idea of what the other partner primary objectives are and gain synergy from working together.



Due to the difficulty of obtaining this kind of detailed information from the cross section of members and stakeholders, and the relative value for each organization to be summarized at a high level, we have chosen to focus on information gathered through NCSLI. Additional input to help prioritize objectives will be sought through further discussions with the Board of



Directors, at Sectional meetings, through a kiosk at the conference, through a website interface and through individual discussions with stakeholders and member organizations. The summary might eventually look something like this. A graph like this would not mean that a ranking of #1 is not important, just that relative to other objectives, a higher level of effort and resources should be placed on the other factors.

Summary & Recommendations

Determine What Success Looks Like

One of the final questions that must be asked after we have faithfully gathered and summarized the needs, drivers, and objectives, is “What will success look like?” The bottom line is that no one really wants a plan or roadmap that identifies key needs and objectives, but does little to ensure that something effective happens as a result of the effort.

Assign Objectives and Track Milestones

Tracking the needs to objectives that will help “solve problems” is important. Further, the objectives must be assigned to key individuals, committees, and organizations with clearly defined milestones and targets. We also need to be able to measure when and if we are successful or whether adjustments in the objectives need to be made. The difficulty in tracking progress is that the effort from many activities may not be evident until many years of effort are expended – and it may realistically take many years of effort to be successful.

The Plan Must Be Dynamic

Another key aspect of planning activities like this is that they cannot be left static – they must be modified and updated as the environment around us changes and as successes are achieved in some areas and plans modified or stopped in others. We need to have a dynamic mechanism to evaluate and update plans on a regular/periodic basis. For example, every 3 to 5 years we need to make a major effort to take stock of where we are.

Appendix A

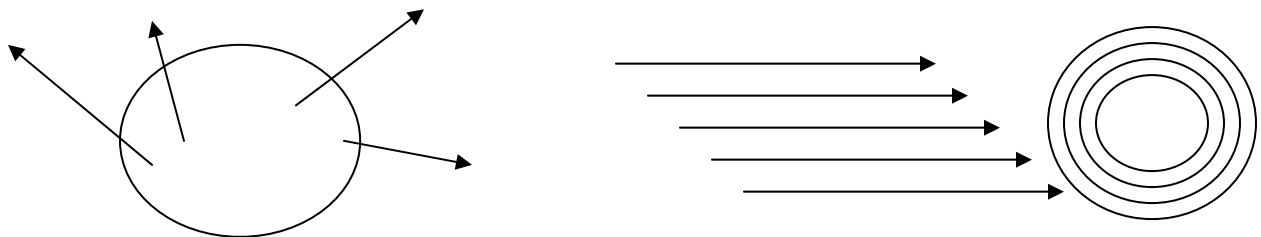
January 2005 Workshop Notes

The following pages of questions and notes were captured in workshops held in January 2005 at a committee meeting held at MSC and the NCSLI Board of Directors meetings. These workshop notes have been posted on the NCSLI website since January 2005 to provide the foundation for continuing development and to solicit additional input. Participants at the workshops were asked to identify critical factors by placing a star next to items they thought should be at the top of the list. Items with (stars) after them indicate the relative priority of the participants in those workshops.

Questions for Workshops at MSC and NCSLI Board Meeting on “Strategic Roadmap for Metrology Training & Education”

Benefits of having a roadmap?

- Easier (and possible) to implement (1 star)
- Set a single direction instead of multiple directions that are unfocused (see diagram below)
- Define what needs to be done
- Decrease chaos
- Increase structure
- The “blue suite” training is gone (military)
- We can assign functions, responsibilities, and tasks
- Minimize reinvention
- Increase efficiency
- Have an end goal
-



Why do we need a roadmap?

- Know where we're going (5 stars)
- Communicate vision (2 stars)
- Know an end point (2 stars)
- We can be organized and efficient (1 star)
- Increase uniformity
- Value added

- Keep goals focused
- Baseline to work from
- Measure our progress
- Working in concert
- Provide a framework for planning
- Avoid duplication of effort

Describe Current Situation & Future Vision

Identify Environment & Trends & Demographics – for now and future?

Who are the stakeholders, customers, and users for metrology training & education? For a roadmap? (Now and future)

Stakeholders

- Industry (1 star)
- Accreditation bodies (1 star)
- American industry and manufacturers
- Government
- Regulators
- Workers, US workers
- Consumers
- Economic viability (of society, industry, governments, etc.)
- Schools
- Military
- Professional organizations
- Unions/contractors
- Standards developing organizations

Characteristics of Stakeholders

- Funding, Finances
- Economic survival
- Need for continuous improvement
- Resources – need for competent employees
- Infrastructure
- Quality of outcomes
- Need for objective evidence
- Confidence in the process
- Regulatory requirements
- Knowledge

Who are the providers? (Now and future)

Personnel and organizations providing training

See <http://www.callabmag.com/schools.html>

(Used to be provided by military)

Instrument manufacturer's role?

NIST and other NMI roles?

Employer role?

Large corporate employer compared with small business?

Who?

Baby boomer generation retiring. Do we capture their expertise before they are gone and/or enlist them in their retirement?

Where are trainers located?

Who currently provides training?

Providers – Session

- Counselors (1 star)
- Schools (1 star) – reactions to industry needs
- Capture experiential education from participating in ISO and other standards development organizations
- Both formal and informal (on-the-job OJT)
- Industry – internal providers; providing to external groups
- Equipment manufacturers
- Professional organizations: ASQ, IEEE, ISA, AIAG, ISWM
- Government – military, NMIs, RMOs
- State W&M
- Consultants, Individuals
- US AID
- Conferences

Characteristics of Providers

- Certified or accredited (3 stars)
- Funded by government (1 star)
- Affordable, cheap, inexpensive (1 star)
- Need direction (1 star)
- NCWM has an instructor certificate program that could be used as a model (GH add-on)
- People skills
- Mentors
- Knowledgeable (or not)
- Well known
- Up to date
- Reputable
- Recognized
- Accessible
- Hands-on
- Ethical
- Experienced
- Needs-based
- Approachable
- Flexible

- On-site

Who are the beneficiaries of metrology training & education? (Now and future)

This is a larger question than just who is trained. The employer, the nation, the society are served. Who can and should pay for it?)

Who are the Beneficiaries?

- Industry (1 star)
- Students (1 star)
- Government
- Workers
- Trainees
- Consumers
- Accreditation members and bodies
- Colleges
- Testing organizations
- Standards developing organizations (SDOs)
- Military
- Regulatory groups
- “the benefit of mankind” – i.e., “survival of species”

Characteristics of Beneficiaries

- Funding, Finances
- Trade
- Educable (or not)
- Need (there is a need NOW)
- Lack of information and knowledge
- Motivation
- Need to satisfy requirements – regulatory and stakeholders
- Recognize the needs – employers, students
- Need to know what they need to know (some do, some don't)
- Awareness levels
- Management support
- Enthusiasm

What (do the stakeholders, customers, users of M&TE think) are (should be?) the purposes & goals of metrology training & education?

SWOT Analysis

Identify Strengths

What is currently working? Why?

What are the strengths?

From Sessions

- Affiliation with other agencies and groups (3 stars)
- Shared subjects – need across communities (2 stars)
- Certification (CCT) (2 stars)
- NCSLI/Metrology culture (2 stars)
- Volunteers (1 star)Multimedia education
- Recognition of need (1 star)
- Cooperation – sharing of non-proprietary information and resources (1 star)
- International and global perspective (1 star)
- Conference & Tutorials (1 star)
- Experience (1 star)
- Academic training (1 star)
- There are providers
- NCSLI products
- Guidance documents
- Legal metrology training
- Section meetings
- NMIs/PTB/RMOs
- Professional organizations
- Mandates & standards
- Mentoring
- Committees
- Nature of technology
- Support from providers (\$\$ and effort)
- Content
- Timing of roadmap effort
- We have technical depth in the community NOW (with a loss potential) (Need actual demographics)
- Enabling developing countries
- Number of people involved
- Technology available to capture expert systems
- Need for legal/validated data
- A level of concern/interest – starting point, culture
- Schools: Butler, Ridgewater, UC Dominguez Hills, Fleming, European universities (Italy, Portugal), Australia, Czech Republic
- Volunteers who have stayed involved
- PMEL pieces
- Board recognition of issues
- Common language (e.g., English, for some)
- Experience – depth and breadth
- Resources

Identify Weaknesses

What is currently not working? And again, why?

What and where are the gaps in metrology education and training?

Describe the Present & Future Issues/Problems that would benefit from solutions.

What are some of the needs in metrology training and education?

- Need a study of what has been done in the past (history of education & training) – 3 stars.
- Identify what is in place.

What are the major gaps you expect to see 10 to 15 years down the road?

Upon what basis do you come to these conclusions?

What are risks and challenges to development and delivery of needed training?

NCSLI is a volunteer operated organization

Education is one of the costs first cut from an organization

Weaknesses from Sessions

- Losing experience (6 stars) (theme #1)
- inconsistent interpretations (4 stars)
- no national “voice” (3 stars)
- lack of personnel resources (trainers) (3 stars) (theme #1)
- Loss of depth (2 stars) (theme #1)
- no national (or international) system (2 stars)
- next crop of educators (1 star)
- lack of glamour (1 star)
- no single vision (1 star)
- military reservoir drying up (1 star)
- Number of people and volunteers have less time (1 star)
- Calibration thinking of management
- “managers” making metrology decisions
- people aren’t available
- PMEL source minimized/reduced (lost)
- “working” less
- lack of depth and width of recruits
- no coordination
- lack of critical mass for class sizes
- lack of reliable demographics)
- not measuring impact
- less income to train
- infrastructural problems
- Less support for E&T
- Less understanding of the need/importance of metrology
- Metrology/calibration has no obvious intrinsic need/value that’s well known
- No continuity within companies

- No standards for training requirements/not portable
- No “Boeing Books” anymore – in the 1960’s there was a significant commitment
- Terminology for calibration and users

Weaknesses in 10 to 15 years

- personnel (2 stars)
- management not recognizing needs (2 stars)
- greater number of labs; including customers and management (1 star)
- excess hours needed/worked
- regulations, union, government requirements vs. voluntary as now
- lack of trained personnel; need data to support this statement; need to capture information and communicate it well
- lack of trained educators
- increased competition for tech jobs
- changing technology impacts on needs
- increased automation
- split/bigger gaps increase among metrology professionals
- \$\$/economy causes cuts in calibration
- increasing out-sourcing (or not)
- lack of public awareness
- lack of metrology standards, QA, curriculum, schools and trainers
- all new technologies
- changing and new requirements
- ability to adapt, delays/gaps
- slow reaction times

Expand on Theme #1 – loss/capturing expertise

- Consider US vs. International perspective (much of our thinking might be US-centric)
- Pay scales for this career path are limited compared to others in science and technology with limited glamour
- Replacement cycles for training new staff are a problem (may take 3 to 5 years in some cases to get people up to speed)
- Need to get new people up to speed much faster than ever before due to turn-over
- Attrition and longevity concerns
- Demographics – current experts are “getting old”
- No replacements; don’t see replacements
- No longer any PMEL output (limited military experts leaving military and available elsewhere)
- Golden parachutes
- # of requests for training continue strong and are increasing
- young people have less motivation and interest to pursue metrology careers
- The foundational education of students getting into metrology appears lower than 10 years ago as indicated by educators/trainers (can we measure this?)

- Consider age/demographics and experience in the NCSLI benchmarking survey (length in service statistics)

Identify Opportunities

General Opportunities from Session

- Build consensus (4 stars)
- Provide a roadmap for everyone to use (3 stars)
- Funding and Federal-State (3 stars)
- Universities – consider metrology tasks as a part of other jobs and curricula (2 stars)
- NSF funding (2 stars) – need Point of Contacts!
- Scholarships (1 star)
- MEP relationships (1 star)
- DARPA replacement and move to future?? (1 star)
- Help with developing countries (OAS/USAID/IAD Bank/World Bank) – e.g., Central and South Americas, the “stans” and Asian market (1 star)
- Collaborate and partner (1 star)
- Increase awareness
- Develop new methods
- Revive the schools
- Books
- Use television (Olympics, Guinness Book of Records, Super Bowl) – calibrate the 10 yd chain at the super bowl, validate the records, consider the measurement requirements for records
- Consider M&TE malfunctions
- Update the S.O.C. – create definitions and grow from lower levels
- The timing of this activity and a window of opportunity
- Dislocated/incumbent workers
- PELL grants
- Increase conference attendance

Describing the Future

What products and services will be needed in the future?

What are possible alternatives that can be used to meet future needs?

What does the Future look like?

What does the future of metrology education and training look like?

What components would be included in an ideal international system of metrology education & training?

What type of training is needed? People needing training not located where training expertise is located. Why?

New technologies coming online faster and faster
Higher precision (nano scale)

What type of training is currently available?

How do we measure the gap between what is presently available and what is needed?

What methods are used to provide training?

Direct human interaction

Hands-on experience with the most modern equipment

Over the internet:

Virtual reality (feel, touch, see)

CDs

DVDs

Instant messaging

Broadband transmission of lectures and discussions

See http://www.ntb.ch/files/1/3451/IMS_Forum_2004_METROeLEARN_NTB.pdf

Why?

Expertise not located where need is?

From Sessions

- Intelligent instruments (3 stars)
- New energy sources (e.g., H₂) (2 stars)
- Micro/nano metrology (1 star)
- Distance learning (1 star)
- FAA and FDA are requiring mandatory education (1 star)
- Increasing number of businesses with certifications like ISO 9000 (conformity assessment activities) (1 star)
- Centralization of organization resources
- Wide geographic distribution of opportunities
- Medical labs are a niche
- Media coverage
- Government recognition
- World standards day, W&M Week, Metrology?? (Big Guns recognition)
- Foreign military sales
- Cost/benefit, return on investment
- Event prediction (earthquakes, tsunamis)
- Individualized training
- Implanted KM chips
- Customized training
- Virtual experiences
- Simulations

- Just in time training
- Space exploration

Technology

How will technology and technical trends affect the needs of metrology education and training in the future?

How much of future training needs will be replaced by “self-calibrating” instruments?

How can we take advantage of web based technologies to facilitate ‘offsite’ attendance / participation at tutorials and seminars? (New revenues – greater access)?

Should we take greater advantage of technology? Is it part of the solution? Is it worth the cost?

How will new technologies provided without knowledge of what accuracies are currently needed or will be needed impact education and training?

From Session

- Non-traditional areas (chemical, nanotechnology, medical) (1 star)
- Smart sensors (1 star)
- Changing instruments and technology
- Increasing precision
- Nanotechnology
- Increasing speed
- Increasing use of IT (data transfer speeds)
- Lower (better) specifications
- Additional disciplines needed
- Remote calibrations
- Wireless calibrations
- Safety issues (ROF, Pb, heavy metals)
- Very low frequency
- Increased ranges of measurements in parameters
- Use of multimedia
- Faster product cycles
- Niche markets (e.g., health)
- CD-ROM, Internet, Cyber, Advanced Delivery Formats
- Self-paced
- Train instrument designers about calibration concepts vs. calibration labs (auto calibrating instruments)

Partners

How can we better partner with other associations (MSC, ASQ, ISA, IEEE, IMEKO, etc.) to help coordinate and promote metrology training & education initiatives?

How can we coordinate and leverage many isolated activities in metrology T&E?

What kind of collaboration should we be doing? With whom?

Are cooperation and collaboration needed now and will it be needed in the future? How?

What if we don't partner/collaborate?

Partnering Ideas from Session

- Collaboration ideas (Theme #7)
- Liaisons (work with our current liaisons)
- Develop a consortium and get NSF funding

Session Topic on Partners – who? How/format?

- Through committees (4 stars)
- IMEKO (1 star); “40% of IMEKO members are in academia” (GC) – find reference
- Courses (1 star)
- NMIs/other government agencies/other organizations (e.g., ASTM) (1 star)
- Contractors
- NCSLI Members
- Accreditation bodies
- Military
- Schools
- Regulators
- Stakeholders/providers/beneficiaries
- Industry/manufacturers
- By trading services (e.g., advertisements)
- Influence
- Contracts
- Use of NCSLI facility
- Consider models from others (e.g., AIAG, ISA)
- Provide fellowships/associates

NCSLI Focus

What are the unique roles for NCSLI?

What should role of NCSLI be?
Expertise to develop training?

Expertise to deliver training?
Potential students?
Operate lending library?
Operate web site?

What should the NCSLI Board be doing?

- Consider the financial impacts and implications (7 stars)
- Membership input, obtain (5 stars)
- use position as a bully pulpit to advance the cause (6 stars) (theme #5)
- lead and coordinate (5 stars)
- Create a roadmap and vision (2 stars)
- Increase awareness of issues and availability (2 stars)
- Set a roadmap (1 star)
- Find national and international partners (1 star)
- develop an education mission statement (1 star)
- explain what it's all about "why be a metrologist" from HS on (1 star)
- provide direction for regions/sections/local providers/schools/students (1 star)
- Set direction
- Create a media campaign
- Provide an organized interface
- Identify sources (education, training, funding)
- Increase/facilitate awareness of trends and changes
- Be a catalyst for E&T
- Assist with management awareness
- Set policy
- Identify gaps
- Advise
- "imperative" assure resources
- define a PR agenda
- identify the boundaries and roles and enable stakeholders/providers
- set policy
- coordinate efforts
- recruiting for content (where missing)

What should NCSLI Committees be doing?

- Work with industry, government, and the military to determine education and training requirements (8 stars) (theme #2)
- Developing publications
- Review charters
- Maintain the resources list, compilations, directories
- Offer scholarships (1 star)
- Provide forums (environment, meetings, opportunities) for metrology education/training
- Compile education and training information from other countries (1 star)

Is the Conference a Learning Event? How?

Personnel Qualifications & HR

Where will new metrology professionals come from? (Consider demographics).

What will be the role of the metrologist in the future?

Will there be metrologists in the future?

What knowledge will be required?

What skills will be required?

What abilities?

In what areas will this not change?

In what areas will this change?

Where are the students located?

Global needs of US military

When do they need it?

Is “just in time” part of the equation, or are there physical skills requiring practice, experience, and expertise (like volume calibration and the reading of a meniscus)?

Who currently has access to training? Who does not?

What measures should be established to determine level of expertise to be obtained by students?

What levels of competency are needed in this field?

What are the needs for evaluating the essential “knowledge, skills, and abilities”?

What are the best ways to define the KSAs?

How do we go about defining the KSAs needed?

What parties should be involved in defining KSAs?

What are the needs for evaluating metrologists (education, demonstrating knowledge, and demonstrating proficiency)?

How can training needs assessments be completed? Who should do it?

Thoughts to Consider from Sessions

- Update the DACUM info from the early 1990s (5 stars) update it; do a better job of agreeing and disseminating the information (4 stars)
- Provide assessment at “levels” (1 star)
- On the triangle of Education/Certification/Proficiency Testing, we need the PT component developed with additional training (1 star)
- Update the classification system (1 star)
- Update the standard occupational classifications (work with Chris/ASQ)
- Update the DACUM (1 star)

- Provide guidelines on how to do PT (to recognize the technician vs. laboratory), develop good practices on this (1 star)
- Develop a measure of hands-on competency
- Test for “common sense”
- Have differing levels of certification
- Expand the CCT (as planned) for metrologists and other specific technical disciplines within metrology/calibration
- Define KSAs for “levels”
- Create national and international standards to identify the levels
- Develop CEUs, credits, degrees
- Problem of being heard (weakness)
- Have certificates of training
- Maintain the CCT
- Unions (weakness)

Education/Training Development and Evaluation

How do the education and training functions contribute to meeting essential KSAs?

Is there added value in training certificates, CEUs, credits, degrees, and certification?

How can and should training needs assessments be completed? By whom?

How should we measure quality of providers? Should we?

- Develop official/recognized/accredited CEUs (3 stars)
- Develop CEUs (2 stars)
- Increase the number of degree-offering programs (1 star)
- Have NCSLI become an accredited CEU provider
- Evaluate content
- Consider implications of “endorsement”
- Evaluate content – a whole committee and system would be needed
- Limited to no evaluation in the past
- Uniformity (weakness)
- Quality evaluation committee
- Unions (?? Context??)

What Threats are we facing?

What are some of the trends influencing future needs in metrology training and education?

Threats from Sessions

- loss of expertise (2 stars) (theme #1)
- budget cuts (2 stars)
- less research and funding (2 stars)

- no articulated career paths for all measurement professionals (1 star) (theme #6)
- lack of glamour and excitement (1 star)
- lack of notoriety (“invisible 3rd man” concept from W&M) (1 star)
- less understanding of needs by management, less interest (1 star)
- cost of incompetence (1 star)
- outsourcing and off shoring
- compromising safety
- conflicting standards
- apathy and ignorance
- Funding, Finances
- 1 big lawsuit related to measurement and negligence
- pay/rewards
- shift of economy to service
- technology bubble – people will go elsewhere
- metrologists looking elsewhere

Resources

How can we gather an “inventory” of available resources? Who should do it? How do we make the information widely available?

Who should pay for training development, delivery, and assessment? How can training development, delivery, and assessment be funded?

See <http://www.browncandsharpe.com/grant/unlock.asp>

Beneficiaries are logical sources for funding

Partnerships with other professional organizations

New roles for professional organizations such as NCSL

What are possible mechanisms and funding sources for curriculum development in “gap” areas?

Are any of these organizations potential partners?

See <http://www.asq.org/perl/index.pl?g=measure>

http://www.nano.gov/html/edu/home_edu.html

<http://directory.google.com/Top/Science/Technology/Metrology/Associations/>

What kinds of things should we measure to assess the availability and quality of metrology education and training?

What resources and information is available that can guide the development of a strategic roadmap for metrology education and training? Who has what? What are they willing to share?

This will provide the direction to be taken in the “road map”.

In 5 years? In 10 years? In 20 years?

Thoughts from Session

- Continue Scholarships (3 stars)

- Seek out grants for development and for partnerships (2 stars)
- Create awards
- Get support from UN/USAID
- Consider economic prospects and career opportunities (1 star)
- Users (beneficiaries) should be the ones to pay for the education and training

Roles

What role should the NMIs play?

What are the roles of the various stakeholders?

At what level should the various providers focus?

Where can expertise to develop, deliver in new ways be found, funded?

At what level should the various providers focus?

(This might focus on where to find additional expertise, partnerships for planning and delivering, even funding and marketing.)

Thoughts from Session (follow the pirate's code)

- Ensure ground rules and decision making process is defined and communicated (2 stars)
- Ensure mutual acceptance of roles (2 stars)
- Mutually beneficial (2 stars)
- Cooperative
- Consider implications of profit/non-profit and 501c3 status
- Role for some is "soliciting"
- Provide conflict resolution guidance
- Need opportunities for schools to show NEEDs

Measuring Success?

How will we know if we are making a difference?

How will we measure improvement in the overall status of metrology education and training?

- There is a supply of eligible technicians who are trained in the right disciplines and the right technicians are in the right places (3 stars; theme #1) Properly resourced (right resources in the right places)
- Have identified career paths (2 stars) (theme #6)
- Increase NCSLI membership (2 stars)
- No more disagreement (reduced disagreement) of measurement uncertainties (how, what) (1 star)
- Educational programs are available at the BS, MS, and PhD levels (1 star)
- Have a national metrology award or medal
- Identify the right metrics to measure success

- People are coming to NCSLI for information
- Increased awareness
- Specialized training is available where/when needed
- Increased awareness of metrology and metrology education and training
- NCSLI is funded by education and training activities

Wrap-up

What solutions or products have not been suggested? Place post-its on “Additional Thoughts”.

Additional Thoughts

- NCSLI should consider teaming with NCSLI members to develop training classes they can offer.
- Will developing training classes by NCSLI be in competition with NCSLI members?
- Think of NCSLI as a catalyst and a channel for education... not in content development that could threaten people who earn their living providing training.
- Do not concentrate on “calibration” training, but “measurement training” – this will attract engineers, scientists, etc.
- Need an automated tool to capture “graybeard knowledge” then organize and make accessible to those who need it.
- Capture experiential that is foundational and pervasive (i.e., independent of specific measurements)
- Use technology to facilitate rapid update of content as technologies change.
- Have a press release – local media kits – posters, CDs – soon.
- What are the next steps?

Thoughts Re High-Level Contacts

- The Canadian study to evaluate future needs of metrology (foundation for Fleming program) – it was difficult to find the right senior level people
- Accreditation may be changing the difficulty of finding high-level people familiar with metrology (management commitment requirements)
- Answer: “what do I need to learn about metrology as a manager?”
- Identify “metrology for management”
- Expand on the concept: Metrology/calibration is a key foundation for all of trade and commerce (earlier said “benefits all mankind” – consider Adams quote).
- Needed for promoting metrology

Thoughts RE Career Paths

- Ongoing education and training is needed to remain accredited, registered, certified
- We need to identify a complete path from early education to career
- High school → college courses → careers
- Related to above (prep courses identified by category and parameter, establish the “need” for people to enter the career, provide adequate salaries to attract and retain)
- Accrediting bodies (for schools) WAS&C (??) plus 4 others accredit schools and evaluate HS curriculum

Miscellaneous Thoughts During Brainstorming

- Focus on Metrology PLUS basic science & technology (3 stars)
- Need a Masters in Metrology Management (1 star)
- Where does Metrology FIT in a university system (need to answer this question) – quality? Science? Engineering? Measurement Courses? “Measurement fundamentals are like mathematics”? (1 star)
- Need management training for the metrology environment
- Need a “guide to the provision of metrological training” (guide for people who are developing metrology training – how to provide good training for this field)
- The Body of Knowledge (BOK) needs to include Quality Assurance, Technical Content (in metrology/calibration) and Management and we need to integrate all of the components
- Consider model used in Mexico (as presented by Salvador Echeverria in SLC04)

Themes Noted

- 1 Loss of/need to capture expertise.
- 2 Identify and determine requirements.
- 3 Funding and resources are available where needed.
- 4 Issues related to providing.
- 5 Communication Issues.
- 6 Career Paths
- 7 Lead, coordinate, work with, partnering, collaborating

Additions –

- Report on what has been done? History of metrology education and training?
- Need demographic projections and trends (vs. anecdotal). Gaps? Competition?
- What resources are available now? No depository or database that compiles all that is currently available through many formats. Training Aids Library, Training Information Directory, additional training resources/references. How can we evaluate the gaps if we don't know what we have and what's missing?
- Need a map of schools worldwide with metrology programs/degrees and with metrology and/or quality courses
- Define terminology (or find definitions): professional development, education, training, continuing education
- What are the next steps – circulate comments from Jan05 workshops; series of focus group meetings; April BOD report; NCSLI conference report and invitation to contribute
- Expand on this concept: need for metrology/measurement understanding by non-metrology professionals (e.g. management) – maybe a high-level objective?
- Media interaction – overlaps with and need for marketing assistance – objective? Increase awareness of measurement infrastructure (greater than an educational issue)
- Consider relationship of needs, assessment, and objectives as related to the national (and international) measurement systems
- 2005 Projects in LRP by Committee: Roadmap (160), Standard Occupational Classifications (163.01), Personnel Guide (163), RP on OJT (163), Educators You

Should Know for Newsletter (160), NCSLI Sessions at Conference (Educator's Forum, CCT, Strategic Roadmap, Unsolicited papers)

- Who are the Education Liaison contacts – Graham Cameron, Jesse Martinez, Burt Sutherland
- History and compilation of scholarship contributions anywhere? Who? How much? Reports? (Treasurer? Office?)

Additional Notes

- NCSLI does NOT market adequately. Member companies don't pass the word down to laboratory personnel. NCSLI needs to recognize this and do better in getting the word out - particularly on our web site.
- The Tutorials have been extremely successful. What can be done to make them even better? I suggest again that there could be better marketing. Many lab personnel I have spoken to would attend a weekend Tutorial on their own nickel. Airfares to the DC area are low from around the United States. Tutorials are low cost. Lodging is relatively low cost. However, there is NOT common knowledge that you can attend ONLY the tutorials and NOT register for the Conference. Our statistics bear this out.
- What can be done at the Regional levels in addition to "Uncertainty Roadshows" to improve? Again, I suggest an expansion of the "Tutorial" program....
- What needs improvement: Laboratory personnel are NOT familiar with "Uncertainty Analysis". We assess to 17025 and often the Quality Manager is the ONLY person familiar with the 17025 requirements.
- Obviously there is a real lack for Metrology formal education. I'm not sure what benefits NCSLI has seen from "scholarship" donations. I don't even know where to look as I have no clue what educational institutions received Scholarship monies.

Session Evaluations

What worked in this session?

- Leadership
- Prepared and circulated materials
- Organized
- Focused
- Directed
- Phone (MSC)

What didn't?

- cookies
- noise in room next door (BOD)
- phone (MSC)
- too philosophical/big picture – no assigned tasks or milestones (yet)
- room configuration, size, acoustics (BOD)

What should be improved?

- Circulate questions (MSC) – done for BOD

Appendix B

Strategic Challenges – April 2005 Draft

Only those portions of the Strategic Challenges that have not previously been included are included in this appendix. This represents many possible tasks or goals that could be used to ensure that we meet the strategic challenges. In some cases, work is already in progress in key areas. In other cases, policy level decisions by the various stakeholders need to be made and collaborative agreements need to be forged before moving ahead. *Disclaimer: The items listed here are DRAFT activities and may not be supported by any or all parties, but were suggested by someone and thus captured for consideration.*

Challenges and Possible Goals

1. *Metrology and Standards Outreach.* Ensure awareness of metrology, measurement sciences, and needs for calibration and standards in such a way that it is readily recognized by organizational managers and the general public. NCSLI should work to increase awareness of metrology, measurement sciences, and needs for calibration and standards in a way that it is readily recognized by the general citizen/consumer.
 - a. Multimedia tools with “cool” metrology-related resources are needed to enhance the “glamour” of the profession.
 - b. Presentations and displays are needed for “career days” that can be used by all NCSLI members. Presentations should be made at non-traditional metrology environments (where high-school counselors gather; university education curriculum programs, science fairs, press releases to meteorologists to talk about measurements (metrology) vs weather (meteorology)).
 - c. Government liaison and organized support for NMIs are needed to ensure ongoing support for metrology, calibration, and standards.
 - d. Promote measurement concepts through media and press releases whenever possible. Target key areas such as: Olympics, Guinness World Records, Sports.
 - e. Promote the metrology (and standards and quality) related awards of various organizations more widely than within the metrology community (press-releases, ads in other professional magazines). E.g., NCSLI’s Wildhack, MSC’s Woodington, IEEE/INMS Morris E. Leeds Award, etc...
 - f. Create additional awards that are cross-organizational and promoted more widely.
 - g. Efforts should be made to partner with the NIST Manufacturing Extension Partnership centers to get measurement concepts integrated into manufacturing processes and to support manufacturers with metrology education and training as needed. Case studies are widely promoted.

2. *Career Opportunities.* Ensure that clear career paths are identified and communicated as widely as possible and to ensure that labor statistics are tracked and available. NCSLI will help define clear career paths for metrology. Metrology (measurement science) as a career path/choice/option must be clear and be clearly communicated to an increasingly

wider audience and the predicted demographics for science and technology professionals must be addressed.

- a. The Standard Occupational Classification system must be updated with clear definitions of related titles and descriptions.
 - b. Sample job descriptions for metrology supervisors, metrologists, metrology technicians (calibration technicians) must be developed and readily available.
 - c. Identify different “levels” of metrology professionals. Map career paths to educational and on-going training requirements.
 - d. Salary benchmarking information must be integrated with titles and job descriptions.
 - e. Compensation requirements need to be evaluated across multiple disciplines and must be commensurate with comparable science/technology positions.
3. *Personnel Qualification.* Ensure that appropriate methods or systems are in place to provide appropriate recognition and credibility for the metrology professions. NCSLI will support efforts to ensure that metrology professionals gain recognition and credibility. Personnel qualification systems are needed, from CEUs, certification, and degrees.
- a. The Certified Calibration Technician program of ASQ needs to be expanded to include a hands-on competency component. This will require a high level of coordination with ASQ in that NCSLI would want an exam commensurate with certain requirements (many questions must be answered: who's owns, manages, maintains the equipment for suitable testing? is it up-to-date? what requirements will someone have to ensure that certification is awarded under agreed-upon conditions? who's proctoring the exam, knows that part of the exam (as a subject matter expert) and watching for successful behaviors? what manufacturer's equipment will be used?) This task is do-able but would require a very systematic approach to sort through all the issues.
 - b. Develop certification or recognition programs for additional levels of metrology professionals and specialists, not just technicians.
 - c. NCSLI should provide a forum for coordinating “individual competency testing” at region/section meetings and at the conference.
 - d. NCSLI should provide a forum for CCT Refresher training to be conducted at meetings and conferences.
 - e. Employers need guidance on the appropriate use (and avoidance of misuse) of educational degrees, certification, and proficiency testing requirements for metrology professionals.
 - f. On-the-job training guidelines for development and documentation of on-the-job and ongoing training activities should be standardized through a recommended practice that can help laboratories comply with testing and calibration laboratory quality systems (such as ISO/IEC 17025).
 - g. Management needs guidance and training on metrology and quality concepts.
 - i. Good management practices need to be developed and communicated to support good measurement practices.
 - ii. Metrology concepts need to be taught in university settings as a part of other programs to ensure that people promoted to management have a

- good understanding of metrological requirements. (Needs to include on-going continuous educational options for first-time managers too.)
- iii. NCSLI should consider a project to develop a course collaboratively among universities and training providers that can be shared among universities and taught by metrology professionals. Offer “Basic Measurement Concepts for Managers” as a Tutorial at a conference and expand from there. (Comment: Nice idea but impractical, in my opinion. Why would any university want to listen to us? It might change somewhat if and only if we have an adequate training library with lots of diverse material. That is certainly not the case today.)
 - h. Instrument designers and engineers need to understand measurement concepts. Metrology concepts and courses need to be integrated into engineering programs.
4. *Metrology Education.* Provide multiple forums for metrology educators to interact, and to encourage sharing of ideas and resources, and to help ensure that stakeholder educational needs are met. NCSLI will provide a forum for metrology educators to help ensure that stakeholder needs are met. Formal metrology education must be more widely available, with greater range of degrees, increasingly flexible with respect to resources, timing, and locations, and will be increasingly collaborative among educational institutions.
- a. Knowledge, skills, and abilities required for the field as developed in DACUM studies must be widely integrated into other activities and communicated to career counselors and educators who are providing metrology-related curricula.
 - b. DACUM studies conducted in differing locations (U.S. and Canada) should be compared and analyzed for gaps and opportunities for enhancement.
 - c. NCSLI should work with government, industry, and providers to determine up-to-date education and training requirements (needs assessments)
 - d. Updated and ongoing studies need to be coordinated among the many stakeholders to ensure that changing needs and technologies are addressed as a part of metrology education.
 - e. Scholarship information and scholarship resources for metrology need wider visibility and centralized promotion (both of the availability and of the awards).
 - f. World-wide sharing of information and collaboration among educational institutions providing metrology training is needed to gain shared recognition of degrees, continuous improvement of courses and curriculum through sharing, and to improve opportunities for collaborative efforts than could receive special funding/grants.
 - g. An Educator’s Forum should be an ongoing component of promoting formal educational programs at the annual conference and could be extended to on-line sharing through use of the NCSLI Forum Comment: for whatever reason – the NCSLI Forums don’t seem to be very popular and they could be expanded or even a Sharepoint system used.)] website and the NCSLI Newsletter (or other print media). E.g., Educators You Should Know.
 - h. NCSLI should support and encourage the development of degree programs in metrology (as major programs or as supporting minors; e.g. engineering degree with metrology focus/minor).

- i. Collaboration among programs in related fields is needed to build on possible relationships and gain synergy among programs and concepts (e.g., electronic instrumentation, medical technology).
 - j. Metrology concepts need to be integrated into many other curricula. Future professionals may require knowledge of metrology concepts as a subset of their full knowledge and skill set.
5. *Training Resources.* Ensure that information and resources on metrology education and training are widely available and to ensure a high level of awareness. NCSLI as a goal will be the premiere source of information and resources on metrology education – the first place the metrology community will refer others to when asked about metrology education and training.
- a. The NCSLI Training Resource Library must be updated with current resources and marketed as a member benefit.
 - b. Training information needs to be gathered (for all formats; especially training courses need to be more dynamic)
 - c. The “Training Information Directory” must change its format to be dynamic and regularly updated, even to the extent of knowledge management systems – portions should be integrated with the NCSLI events calendar, portions should be promoted in print and multimedia to a wider community to increase awareness, information must include all media formats.
 - d. Links to current on-line resources need to be integrated.
 - e. Add ability for users to add on-line “reviews” of training resources and training classes. (E.g., give a class one to five stars.)
 - f. Create a virtual library of references that includes papers from technical sessions at the conference – available to members only. A lot more material is required to make this worthwhile. But how do we get that material or who is willing to generate it?
6. *Training Opportunities.* Ensure development, implementation, and recognition of real-time (fast-response) metrology training. NCSLI should be a catalyst to ensure that additional opportunities for real-time (fast-response) metrology training are developed, implemented and recognized.
- a. A formal training “needs assessment” should be conducted and results published.
 - b. Use of the NCSLI Training Center needs to be developed further. Additional webcasting, satellite, or teleconferencing equipment should be considered in the future. This should be developed along the lines of space we use to educate versus space we rent.
 - c. Development and promotion of tutorial sessions at the conference needs to be continued. Use the success of this program as a springboard to accomplish many of the efforts in this plan.
 - d. Opportunities for section meetings to include more formal training (in addition to presentation of technical papers) should be promoted.
 - e. Collaboration with member providers to market recognized training opportunities is needed.

- f. NCSLI should consider current and future regulatory requirements and potential for collaboration in the GMP, FDA, and FAA environment with respect to metrology education and training needs.
7. *Training Assessment & Certification.* Develop and provide an infrastructure for assessment (and certification) of metrology training courses. NCSLI could develop an infrastructure for the assessment of metrology training and for providing continuing education units as value-added for training courses and which are required as a part of on-going educational requirements.
- a. Determine whether CEUs provide value added to the metrology profession. What is the usefulness of CEUs? Who needs them and what industry is using CEUs as valid educational credits?) Get CEUs working within NCSLI before we offer them?
 - b. Metrology professionals would like a system that evaluates the metrology training and credibility/value of metrology training that is available as well as providing information as to the targeted audience (management, metrologist, and technician). Providers and/or courses could be certified or accredited.
 - c. NCSLI should develop an accredited (IACET) program for offering continuing education units for metrology training courses (includes responding to requests for CEUs from NMIs, MSC, ASQ, NCSLI Members and liaisons who provide metrology training).
 - i. This program requires assessment of training and assessment of students completing the training).
 - d. NCSLI should develop a guide for ensuring high-level quality in metrology training. (What should be included in a good metrology course? How should it be taught? Is NCSLI really in a position to do this? What gives us the authority to set-up such a guide?) If NCSLI is awarding CEUs for a course taught/given/provided by a third party, it will have already matched lesson objectives/content to some 'career path' or purpose as well as the delivery method and instructional strategies should also have been defined... so not sure this is necessary unless too many third party vendors are having course rejected ...
 - e. NCSLI should compile available training resources, industry needs, and perform a gap analysis to identify developmental needs (for providers to use and develop).
 - f. NCSLI should develop and implement an “instructor certification” and evaluation program for metrology trainers. Who is going to be the evaluator of the trainers? What happens when the first one is rejected or not approved?
8. *Knowledge Management.* Ensure that critical infrastructure needs for ongoing knowledge management are in place and flexible enough to capture and widely disseminate metrology expertise. NCSLI will help identify critical infrastructure needs for ongoing knowledge management, particularly based on current and future demographics. Metrology knowledge and technical information from an aging workforce needs to be captured in multiple media before it is lost.
- a. Identify opportunities for individualize, customized training.
 - b. Virtual learning experiences are and will be possible.
 - c. Simulations will be developed.

- d. Advanced delivery formats (Multi-media and on-line resources now) are needed with immediate access on focused topics (instruments, procedures).
 - e. An automated tool should be developed to capture knowledge, experience, and wisdom of aging professionals.
 - f. Consider Learning Management System (LMS) options for NCSLI and members or collaboration with others who have an LMS infrastructure in place.
9. *Technology Trend Analysis.* Ensure identification of potential education and training needs in support of measurements and standards needed for new technology infrastructures. NCSLI should work collaboratively with its members to help identify future and cross-disciplinary technologies on an ongoing basis to ensure that education, training, and standards meet the needs of metrology professionals. Consider the current and future needs of the National Measurement Systems (international measurement system) and report on them.
- a. Biotechnology.
 - b. Nanotechnology.
 - c. Software integration, development, automation. Increasing use of IT in instruments and in training. Wireless and remote calibrations.
 - d. Intelligent instruments.
 - e. New energy sources.
 - f. Chemical measurements.
 - g. Medical environment.
 - h. Science and technology policy.
 - i. Food and water technologies.
10. *Collaboration.* Ensure that the entire metrology community and stakeholders work together to gain synergy in achieving our goals. NCSLI will be a driving force to promote collaboration among stakeholders and ensure long-term metrology education and training objectives are met. TEAM concept: Together Everyone Achieves More.
- a. NCSLI and ASQ should team up to ensure that the U.S. Standard Occupational Classification system is updated. Results (products) should be published and shared widely and internationally.
 - b. NCSLI CEUs can be provided to other organizations offering metrology-related courses, seminars, and workshops (e.g., MSC).
 - c. NCSLI conferences provide a forum for metrology providers (educators, developers, and trainers) to gather and collaborate.
 - d. NCSLI website (Sharepoint, teleconferences, provides a forum for metrology education and training interaction.
 - e. MEP centers and available workforce training grants provide a useful framework for collaborative efforts.
11. *Funding.* Ensure that adequate resources are available to support metrology education and training. NCSLI should coordinate efforts in metrology education and training to gain synergy and obtain additional resources for the benefit of ensuring that long-term education and training needs are met.

- a. Scholarships and award winners should be continued and promoted. NCSLI should ensure that metrology-scholarships are included among scholarship resources.
- b. Grants for metrology education should be pursued and developed.
- c. Low-interest student loans to metrology students could be considered.
- d. Models for collaborative partnerships should be developed with joint or shared contributions for funding projects.
- e. NCSLI should apply for grants for pursuing key activities as defined in these strategic objectives. Creative projects and ideas should be listed and prioritized:
 - i. Update DACUM with international and updated perspective.
 - ii. Development of teleconferencing and webcasting facilities in Boulder for the use of educators and trainers.
 - iii. Development of a multimedia package to promote metrology as a profession (incorporate occupational classifications, job descriptions, links to educators and training resources, salary and benchmarking information, member organization websites, video clips).
 - iv. International assessment of metrology education and training resources and gap analysis and report.
 - v. Collaborative development of training resources in specialized technical areas where gaps have been identified.
- f. Winners and scholarship awards should be more widely promoted.
- g. Solicitation for donations and matching donations for metrology scholarships should be considered.