Standards Ecosystem for Nano- and Micro-Manufacturing:
Key Components in the Bridge to Commercialization

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Any opinions expressed in this talk are my own and are not necessarily those of NIST nor of any other organization cited.

Outline

- Why Standards and Associated Measurements Are Important
- Challenges
- Pre-Existing Conditions
- An Example – MEMS terminology
- Standards Developers
- Standards Education
- Conclusions

Significance of International Standards for Nano- and Micro-Manufacturing (NMM)

- **Global competition is intense.**
- **Standards are significant enablers for commercial success at all stages of innovation - from R&D to recycling/disposal.**
- **Successful innovation in technologies for NMM requires standards based on the best available science and engineering. Standards not so based may constrain Innovation and entrench inadequate technologies for NMM.**
- **Documents that accompany standards, especially those on consensus specifications, advance the field and accelerate commercialization and thereby job creation.**
- **Standards influence R&D and business models.**

"Standards enable innovative products and new markets." –
Patrick Gallagher, NIST Director, November 2009

NMM technologies:
Convergence of Many Emerging Technologies

Challenges:

Involve relevant players and stakeholders in international standards and associated measurements

Collaborate and cooperate globally - essential.

Establish decision making procedures.

Build consensus and priorities to accommodate limited resources.

Account for varying national and regional priorities.

Develop standards based on sound science and engineering principles and on reproducible measurements with traceability to one or more national measurement institutes.

Pre-Existing Conditions Needed for Successful Standards Development – the Bridge to Commercialization

- **Market potential of the technology selected for commercialization is great enough to justify the use of resources for standards development**
- **The selected technology is mature enough for pre-competitive effort to develop standards and associated measurements.**
- **The existence of a community of industry leaders who believe the full potential of the technology can be better achieved at less cost and in less time by working together to align the supply chain towards a common vision – standards and supporting measurements.**
- **Leaders must see themselves as stakeholders and be willing to provide adequate resources for standards development and to reward those who contribute to standards development.**

Pre-Existing Conditions Needed for Successful Standards Development – the Bridge to Commercialization
(continued)

- **Stakeholders are willing to share not only resources but also information and knowledge needed for supporting the standards and associated metrology development process.**

- **The existence of a well-defined process for generating consensus of opinion on expected progress and timing needed for critical milestones to be met among a majority of the stakeholders; that is, stakeholders agree on performance metrics (figures of merit) and trends to assess progress towards standards and metrology goals.**

- **A manageable set (not too many) of commonly used technology drivers (performance figures of merits) with known ways to measure them for verifying compliance with standards.**

Meeting many of the pre-existing conditions leads to progress in less time –

An Example from MEMS Industry Group (MIG)

Survey identified the challenges associated with manufacturing the next generation of MEMS based sensors.

One finding - MEMS device testing and calibration consumes 30 % to 60% of the manufacturing cost.

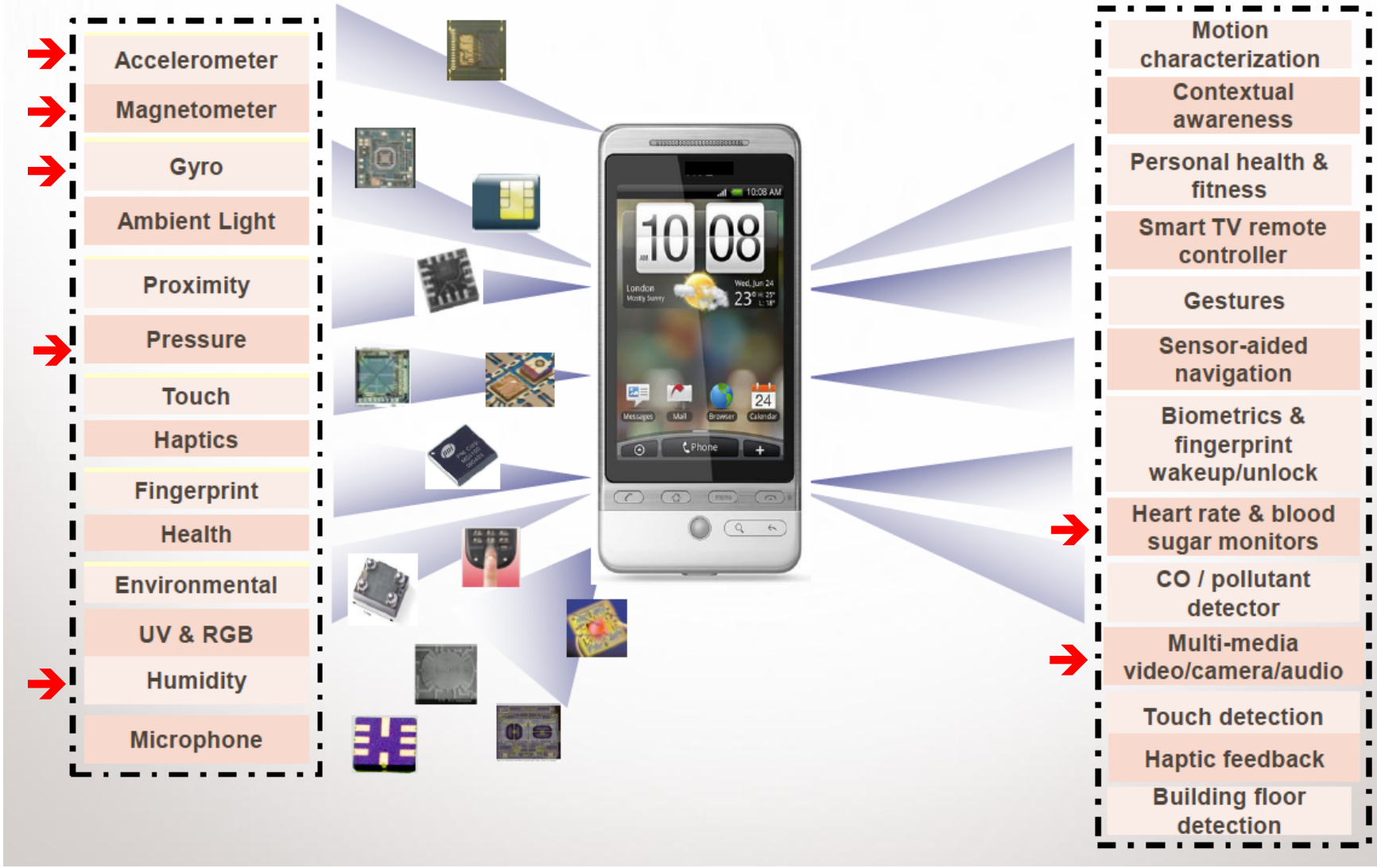
Cost effective packaging, testing, and calibration all require standards and measurements.

Recognizing that such sensors cannot easily proliferate across market sectors without standardization and using the survey results , MIG members prepared the first terminology document that identifies the performance parameters (figures of merit) for data sheets/specifications to be used in fair marketplace transactions between sellers and buyers.

MIG released this document to the public on 2 May 2013.
http://online.wsj.com/article/PR-CO-20130502-912835.html

Because MIG is not a standards development organization, the next steps will be to have MIG work with an appropriate standards organization to publish the document and then to begin defining and standardizing the testing protocols.

Sensors Trends for Handsets



Adapted from Slide 8, *Sensors System Integration Challenges*, C Puig and L. Sheynblat, April 18, 2012

More-than-Moore Applications

From ATA Telemedicine and e-Health News Alert, 26 October 2010: According to Kathy Calvin, Chief Executive of the United Nations Foundation, mobile phones have the potential to "have as big an impact on global healthcare as Sir Alexander Fleming's 1928 discovery of penicillin."

– involves the MtM domains of RF, AMS, bioelectronics, MEMS based biosensors, and actuators.

http://www.liebertpub.com/products/product.aspx?pid=314

More-than-Moore Applications

US and European regulators clear Proteus 'smart pill' – July 2012 - A digestible MEMS sensor within the tablet, which is activated by stomach acid upon ingestion, is able to transmit data via wireless and Bluetooth connections to a patch worn by the patient, and from there, to a smartphone or a doctor's computer. – involves the MtM domains of RF, AMS, bioelectronics, MEMS based biosensors, and actuators.

International Standards Developers – The Four Big I's

IEEE-Standards Association (IEEE-SA) – one member one vote and/or one company/entity one vote; easy access to over 400,000 technical experts through the IEEE technical societies and councils

IEC – one country one vote

ISO – one country one vote

ITU – one country one vote

A GRAND CHALLENGE –
An example from nanotechnologies

Sustaining effective communication, cooperation, and collaboration among all the global stakeholders – essential to avoid the overload of overlaps or *who is doing what*?

Many Technical Committees/Working Groups on nanotechnologies co-exist:
IEEE-Standards Association
ISO
IEC
OECD
JEDEC JC-14 Quality and Reliability – before 2001
ASTM International Committee E56 on Nanotechnology
SEMI
ANF
And this list goes on and on and on ……. .

The Standards Development Lifecycle

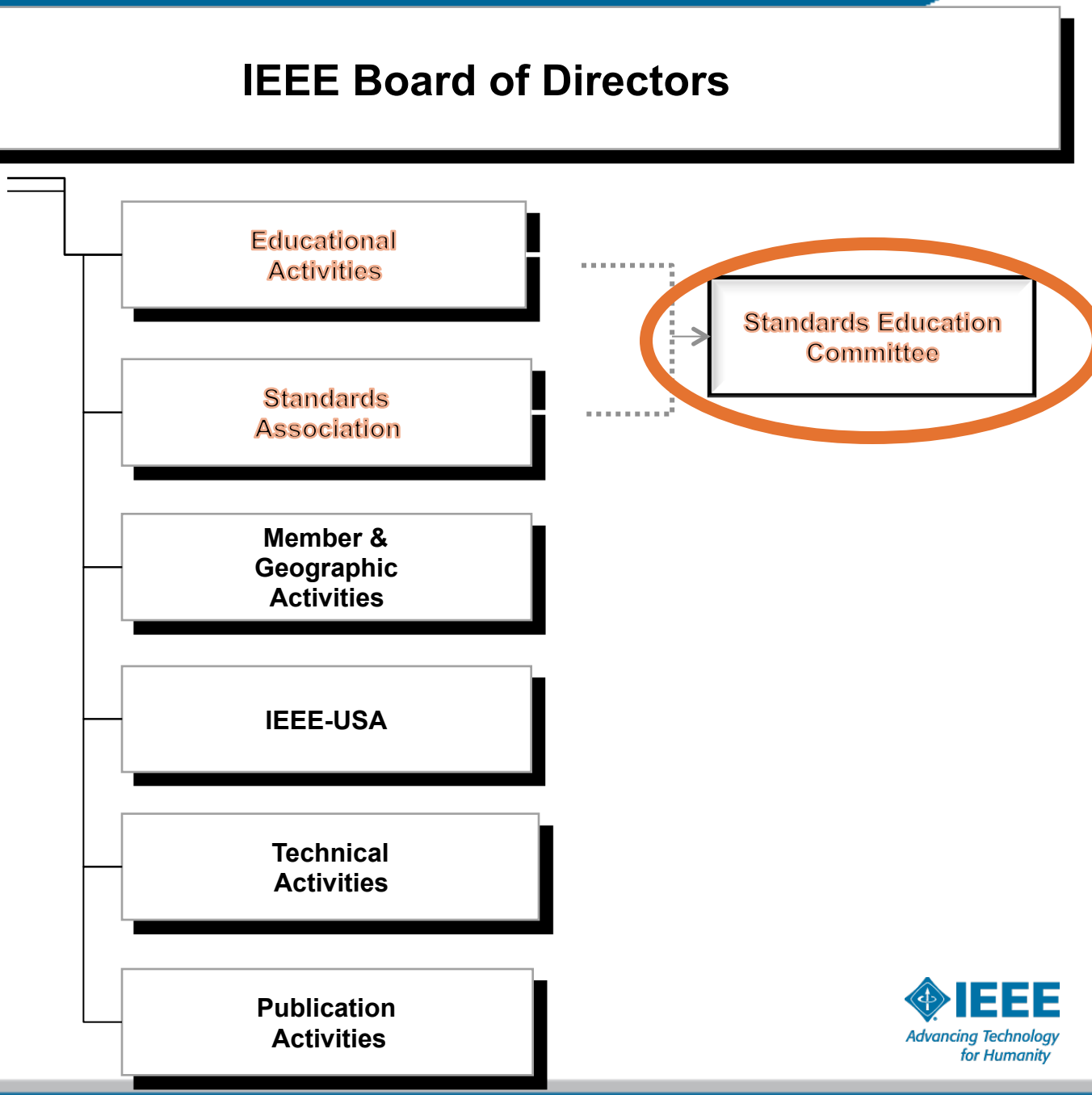
Why Standards Education Is Important

- Standards education recognizes the key role standards play within the engineering, technology and computing fields.
- Knowledge of standards can help facilitate the transition from classroom to professional practice by aligning educational concepts with real-world applications.
  - Facilitate Communication
  - Uniformity for Professional Tasks
  - Foundation/Framework for Innovation
  - Product Quality and Interoperability

Incorporating Standards into Engineering Curriculum

- Exposes students to how an industry segment operates in certain technologies.
  - Students acquire skills necessary to enter workforce
- Benefits students and faculty mentors as they face challenging design processes.
  - Common grounds for discussion
- Prepares students for applied research.
  - Avoids wasting time on inventing/re-building "reusable" technology
- Provides tools for use in learning about standards and their impact on design and development
  - Going beyond theory

Standards Education within IEEE Board Structure



IEEE
Advancing Technology for Humanity

SEC Approach

- SEC attempts to reach its audiences at the grass-roots level through
  - IEEE Standards Education Grants (Student Application Paper Grants)
  - IEEE Standards Education eZine
  - Standards Education Speakers Bureau
  - Collaboration with other SDO/SSOs
  - Developing products/services for universities

IEEE Standards Education Grants

- Grants for Student Application Papers Applying Industry Standards
  - To support undergraduate and graduate design projects, or development/research projects, in which industry technical standards are applied to complete the project.
  - Students receive $500 and faculty mentors receive $300 honorariums.
- Proposal and final report must illustrate how specific standards were applied to a task in the project
- Students and/or faculty describe how standards impacted the design process
- Results are published as Student Application Papers

  http://standardseducation.org/applications

IEEE Standards Education on the Web

IEEE Standards Education Portal

http://www.standardseducation.org

Focal point for delivery of information

Focus on education about standards

Content is available at No Cost.

Developed with the support of US National Science Foundation Grant (NSF)

Collaboration with other SDOs

ANSI Committee on Education

- First Standards Education event at ANSI World Standards Week
- IEEE members of ANSI CoE actively engaged
  - Judging paper competition
  - Finding participants for the consensus simulation event

Collaboration with other SDOs

IEEE-ITU Standards Education Internship Program under Development

- SEC proposal to ITU accepted in 2012
  - Establishment of an Internship Bureau to link companies looking for engineering interns with students looking for internships
  - Focus on students in India
- Full plan currently under development
- Looking toward MOU signing in 2013
- With first interns to begin work in 2014

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IEEE Agreements with IEC - IEC/IEEE Dual Logo Agreement

The agreement, originally aimed at identifying suitable IEEE standards and draft standards as candidates for processing through the IEC full-consensus procedure at the country level, has been expanded to include the joint development of new or existing standards in parallel in both organizations. The agreement involves a dual-logo arrangement in which the logos of both organizations will appear on documents adopted by and jointly developed with IEC. More details at http://standards.ieee.org/develop/intl/iec.html

And with ISO

ISO/IEEE Partner Standards Development Organization (PSDO) Cooperation Agreement

http://www.ieee802.org/minutes/jul2008/opening_reports/psdo1.pdf

CONCLUSION

- **International consensus-based standards offer ways to:**
  - **to determine priorities for investing in measurement science and**
  - **to remove technology gaps between what is available and what markets require.**
- **In order to deliver its full potential, nano- and micro-manufacturers need improved industry, university, and government collaborations; especially in packaging, testing, reliability, durability, standards, and measurements to support high-volume, low-cost manufacturing.**

THANK YOU