Request for Information: NNI Nanotechnology for Sensors and Sensors for Nanotechnology Signature Initiative

- RFI released on October 1, 2013
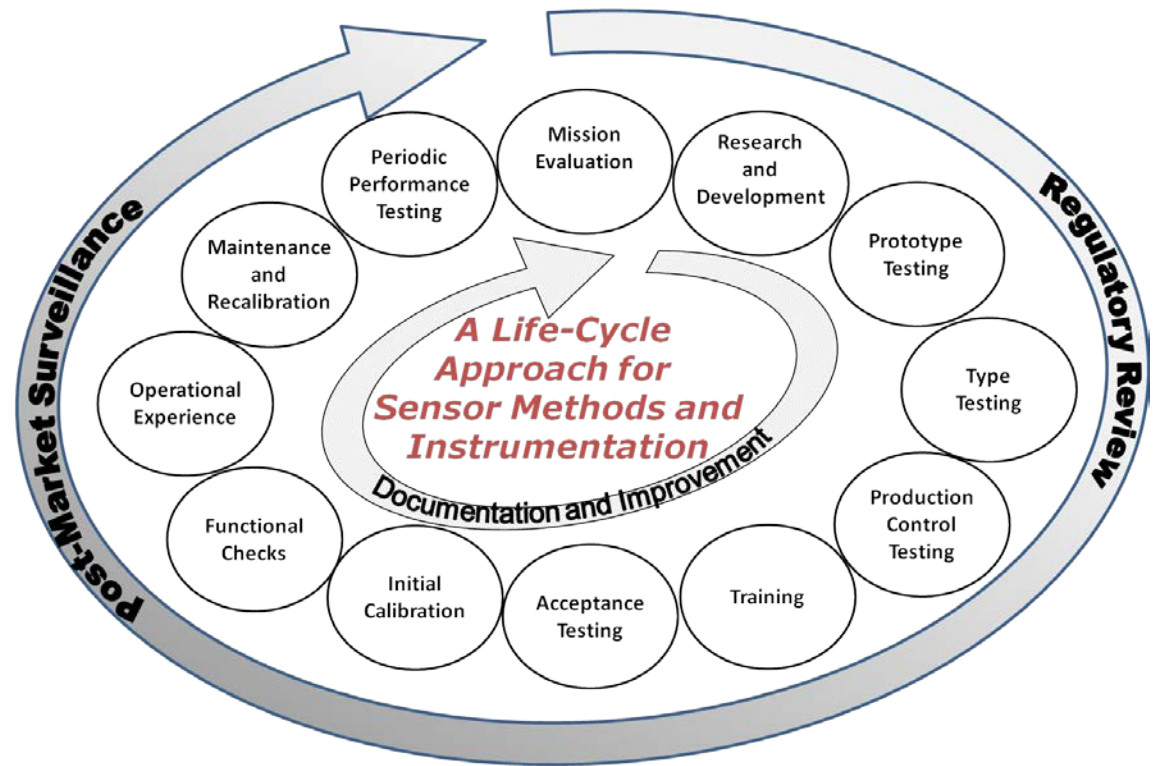- Sensor Development Life-Cycle

Standards

Testing

Manufacturing
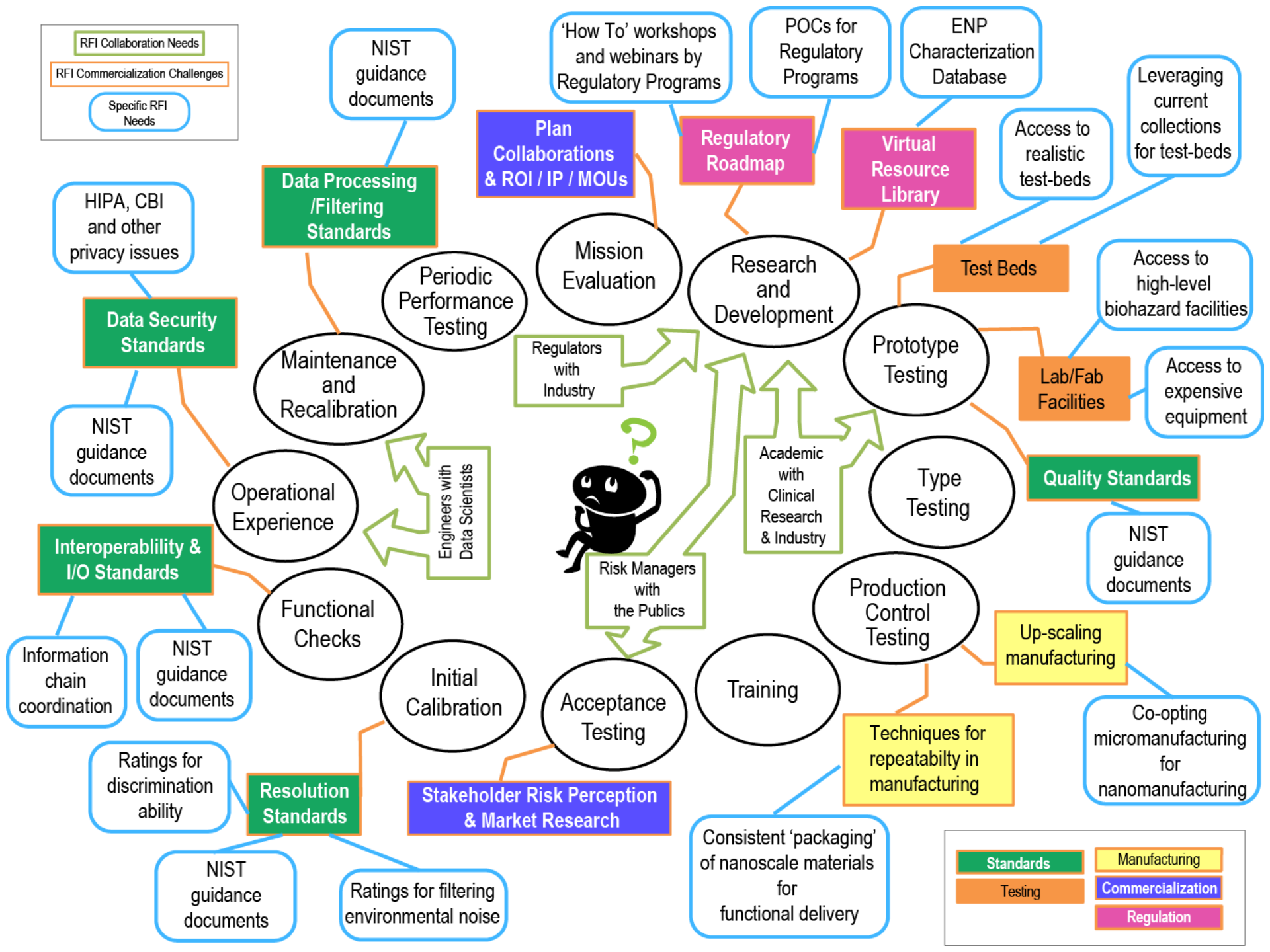
Commercialization

Regulation

RFI Questions

- What are the existing resources, facilities and capabilities for sensor development?

- What are current testing and manufacturing practices in sensor development?

- How well do the existing resources, facilities and capabilities meet sensor development needs?

- What new resources, facilities, capabilities are needed?

- How can we prioritize among needs?

- What are the new tools, processes and applications for sensors that will have the largest immediate impact?

Snapshot of Responses to RFI

- 10 responses received by December 18, 2013
  - Academic researchers, trade groups
  - Technical experts, social scientists, industry representatives
- Major topic areas
  - Technical development of nanotechnology-enabled sensors
  - Nanomaterial characterization and categorization
  - Commercialization and adoption of new technologies
- Responses will still be accepted
  - www.nano.gov/NSISensors

Legend (top left):
- RFI Collaboration Needs
- RFI Commercialization Challenges
- Specific RFI Needs

Central nodes (ellipses):
- Mission Evaluation
- Periodic Performance Testing
- Research and Development
- Maintenance and Recalibration
- Prototype Testing
- Operational Experience
- Type Testing
- Functional Checks
- Production Control Testing
- Initial Calibration
- Acceptance Testing
- Training

Boxes and labels:
- NIST guidance documents
- 'How To' workshops and webinars by Regulatory Programs
- POCs for Regulatory Programs
- ENP Characterization Database
- Leveraging current collections for test-beds
- Data Processing /Filtering Standards
- Plan Collaborations & ROI / IP / MOUs
- Regulatory Roadmap
- Virtual Resource Library
- Access to realistic test-beds
- HIPA, CBI and other privacy issues
- Data Security Standards
- NIST guidance documents
- Test Beds
- Access to high-level biohazard facilities
- Regulators with Industry
- Lab/Fab Facilities
- Access to expensive equipment
- Engineers with Data Scientists
- Academic with Clinical Research & Industry
- Quality Standards
- Interoperablility & I/O Standards
- NIST guidance documents
- Information chain coordination
- NIST guidance documents
- Risk Managers with the Publics
- Up-scaling manufacturing
- Ratings for discrimination ability
- Resolution Standards
- Stakeholder Risk Perception & Market Research
- Techniques for repeatabilty in manufacturing
- Co-opting micromanufacturing for nanomanufacturing
- NIST guidance documents
- Ratings for filtering environmental noise
- Consistent 'packaging' of nanoscale materials for functional delivery

Legend (bottom right):
- Standards
- Manufacturing
- Testing
- Commercialization
- Regulation

Common Themes

- Sensors are the backbone of the internet of things
- Data security will be crucial for acceptance of ubiquitous sensing
  - Important role for regulators
  - Potential of wide access to sensor data
- Realistic test beds are needed
  - Capture conditions beyond standard lab capabilities
  - Access to expensive testing equipment
- Lack of reproducibility of synthesis and packaging of nanomaterials is a serious challenge
- Better communication and collaboration between stakeholders is needed

Specific Concerns

- Standards are missing or used *ad hoc*
    - Unit or measurement of sensitivity
    - Individual sensor vs. network sensor standards
    - Toxicity metrics and measurement protocols
    - Disposal procedures
- Standards needed for interoperability and data security
    - Up and down the supply chain
    - Complementary applications/devices
- Access to biohazard labs for testing is needed
- Difficulty in identifying contacts in regulatory agencies

The Future of Sensors

- Consensus didn't emerge on area of most likely immediate impact
  - Biomedical applications (precision medicine)
  - Physiological/metabolic sensing
  - Gas sensing
  - "Agrifood" safety, purity and chain supply
- Distributed networks of sensors
- Both existing fabrication and new printing/making technologies are being deployed for sensors
  - Fabrication technique will be driven by specific sensor application
  - Standardized packaging

Sensors for Nanomaterials

- Detect nanomaterials and track material lifecycle
  - Detection and recognition in environmental matrices
  - Start and end of life (factory to landfill)
- Recognize nanoscale properties
  - Distinguish nanomaterial from chemical species
  - Characterize nanomaterial
  - Distinguish types of nanomaterials
  - Distinguish engineered from incidental
- Critical for safety and quality control in nanosensor manufacturing

Extra Slides

Standards Questions

- What existing standards have helped to improve or illustrate sensor performance in meeting desired specifications?

- What existing standards have helped to improve the manufacture of sensors (statistical process control)?

- What standards need to be developed (for performance or manufacturing) to meet industry/consumer expectations for emerging sensor technologies?

Testing Questions

- How are you evaluating sensor performance?

- What facilities for standardized testing (e.g., testbeds) have you used to develop nanosensors?

- How did the testbed (formal or informal) help to improve sensor performance or manufacturability?

- What additional testing facilities would aid the sensor development community?

- What capabilities would be highest priority if new sensor testing facilities were to be developed?

- What sample types have you utilized to develop convincing demonstrations of sensor performance (e.g., real clinical samples, environmental samples/sites) and how were these samples obtained?

Manufacturing Questions

- What are the largest technical challenges in scale up and manufacturing facing sensor development (e.g., integration, reliability)?

- What are the new tools for integration/engineering (e.g., Wi-Fi, programmable logic, signal processing software, etc.) that will have the greatest impact on sensor commercialization?

- What, if any, unique workforce issues might be expected for sensor manufacturing (e.g., cross-trained integrators/engineers, etc.)?

Commercialization and Regulation Questions

- What are the commercial applications where nanosensors will likely have the most immediate impact?

- What are the primary contributing factors to the existence of a "valley of death" for sensor development and commercialization (e.g., reliability, potential market size, investment capital, etc.)?

- How can regulatory requirements be best shared with the sensors community?