Review of the Manufacturing-Related Programs at NIST

Summary of the Report by the NRC Panel of the National Academies

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Review of Manufacturing-Related Programs at NIST

Scope of Review

The Panel's assessment included manufacturing research at NIST broadly, with emphasis on the following advanced manufacturing areas:

- Nanomanufacturing (including Flexible Electronics)
- Smart Manufacturing (including Robotics)
- Next-Generation Materials Measurements, Modeling, and Simulation

Review of Manufacturing-Related Programs at NIST

Charge by NIST to the Review Panel

- Assess the technical merit and scientific caliber of NIST's manufacturing programs relative to comparable programs worldwide
- Assess the efficacy of NIST's engagement with outside stakeholders
- Assess coordination and cohesion across NIST of programs in the specific Advanced Manufacturing topics

Key Findings: Nanomanufacturing

- Technical merit, scientific caliber of research: Among the best in the world
- Equipment and facilities: Very impressive; a unique resource; a great national asset
- Area lacks overall ownership under a clear leader.
- Area lacks self-identification: Lacks clear definition of what Nanomanufacturing means.
- Area presents as a collection of projects: Lacks organization from Nanomanufacturing perspective.
- Choices should be made on area scope and topics to pursue
  - Selection process should also decide what not to do — remember X-ray lithography and high-temperature superconductors.
  - When making choices, should include critical mass among criteria and avoid spreading too thin.
  - Good to maintain focus on NIST's core mission: measurements techniques, standards, reference materials.

Key Findings: Nanomanufact. (Cont.)

- In addition to focus on current semiconductor technologies, should also work with industry to develop metrics for benchmarking potential next-generation technologies.
- Should have better coupling with DOE's PV centers (PVMC-Albany, BAPVC-Stanford) — NIST has much to offer in standards, technology roadmapping, manufacturing support.
- Biomanufacturing program, although in its infancy, is ideally suited to leverage current research in protein science and cell biology for new drug development.
- As a resource for industry: Should develop sound criteria for saying "yes", placing emphasis on NIST mission and technical uniqueness, and avoiding being used as a low-cost provider of scientific expertise and advanced technical facilities.
- Increase awareness of "bankability": Should avoid projects that may provide exciting research opportunities but are weak in manufacturability and/or commercialization potential (too expensive, insufficient market size). Same examples apply again.

Key Findings: Smart Manufacturing

- Technical merit, scientific caliber of research: Team is highly qualified and competent. Publications are in leading journals.
- Equipment and facilities: Well equipped to meet program needs.
- Level of maturity of thrust areas lags significantly behind industry state of the art.
  - Examples: Additive manufacturing and robotics.
  - In this lag, what role is being played by the need for new capital equipment?
- Should expand scope of materials in fabrication projects; current efforts seem to be limited to metallics.
- Program metrics should be more meaningful and quantitative; currently they seem to be only project milestones.

Key Findings: Smart Manuf. (Cont.)

- Engagement and communication with stakeholders and customers is primarily through standards committee meetings, industry workshops, etc. These vehicles for interaction are not sufficiently structured and targeted.
- More effective engagement through visits *to* companies with well planned agendas is needed. (Note: Visits *by* companies to NIST will be less useful.)
  - A few visits to companies have occurred; these should be increased and take place *before* undertaking significant projects.
- Key rationale behind above impression: To make sure the problems NIST is working on are important.
- There is periodic coordination between different NIST laboratories. This should be more structured.
- A well defined process is needed for determining and prioritizing projects that should be undertaken.

Key Findings: Next-Generation Materials

- Technical merit, scientific caliber of research: Equal to the best in the world, both academia and industry.

  Post-doc positions are highly sought after; they are important outreach.
- Quality of data, models, and equipment used: Among the best in the world; excellent repository and gatekeeper of scientific data from multiple sources.
- Numerous impressive accomplishments, e.g.:
  - partnerships with automotive, semiconductor, and construction industries.
  - vast scope of length scales.
  - top-notch quality of reference materials.
- Development of computational mechanics and manufacturing should be expanded. Program's partnership with industry should be strengthened to identify future challenges.
- Number of global standards increasing: Working with other international agencies, NIST can take lead in consolidating and simplifying the large number of standards, and perhaps even providing them for profit.

Key Findings: Next-Generation Materials (Cont.)

- Material Genome Initiative: NIST has the best expertise and resources, and should play the leading role; has the capability but lacks enthusiasm.

  Interaction with industry should be stronger. A targeted workshop with carefully selected participants and tight agenda would be beneficial.

- Program organization and management should be improved, with emphasis on rationale and objectives in selecting projects, and clear metrics in judging progress.
- Collaborations with other NIST units are strong and coordination is encouraged and effective.
- As in other areas, increase awareness of "bankability": Should avoid projects that may provide exciting research opportunities but are weak in manufacturability and/or commercialization potential (too expensive, insufficient market size). Same examples again.

Key Findings: Overall Summary

- Technical merit, scientific caliber of research: Teams are highly qualified; among the best in the world. Equipment and facilities: A national asset.
- Project selection: Vetting process should be improved, with greater attention to industry need, manufacturability, and commercial potential.
- Organization: Programs give appearance of collection of projects. Ownership and leadership of programs should be stronger.
- Program metrics should be more quantitative. Some appear to be merely project milestones.
- Interaction with industry should be expanded, with more visits *to* companies and greater awareness of industry practices.
- Coordination across NIST laboratories is broad but seems *ad hoc* and informal. Greater benefits would be realized with structured coordination.
- For its technical and scientific capabilities *and accomplishments*, NIST deserves more national visibility than it gets. Possible reasons: lack of enthusiasm to claim leadership; institutional modesty

Manufacturing: A National Priority

- Because the vast scope of manufacturing encompasses a wide array of disciplines, systems, applications, and environments, contributions made by NIST impact the U.S. industry in a multitude of ways. As a result of its highly qualified researchers and advanced facilities that are a national asset, NIST is uniquely positioned to support U.S. manufacturing broadly.

- Perhaps it is as a recognition of these capabilities that in the recent launch of the Advanced Manufacturing Partnership (AMP) initiative by President Obama at the recommendation of the President's Council of Advisors on Science and Technology (PCAST), NIST has been rightfully accorded a leading role in being selected for the Advanced Manufacturing National Program Office.