NIST: Building a Solid Foundation

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The National Institute of Standards and Technology (NIST) is a nonregulatory federal agency within the US Department of Commerce. Its mission is "to promote US innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life" (www.nist.gov/public_affairs/mission.cfm). Founded on 3 March 1901 as the National Bureau of Standards (NBS), it was the US Federal Government's first physical science research laboratory (www.100.nist.gov).

For over a century, NIST has made significant contributions to the world of science and technology, affecting not only US businesses and the economy but also the general public.

NIST Contributions

A variety of today's products and services—ranging from smoke detectors and atomic clocks to smart electric power grids—employ NIST technology, measurements, and standards. Key examples include computer chips, automated error-correcting software for machine tools, image processing technology, advanced nanomaterials, and pollution-control technology. NIST has also helped define cloud computing, producing a reference architecture and guidelines for using the cloud.[1–3] Furthermore, in the healthcare sector, NIST research has helped produce DNA diagnostic chips, electronic health records, mammography X-ray standards, scanning tunneling microscopy, and high-speed dental drills (www.nist.gov/centennial).[2] Here, we provide a snapshot of the impact of NIST's contributions over the last century.

Industry

NIST's research, standards, and events have influenced and benefited financial services, telecommunications, aerospace, medicine, manufacturing, and the US marketplace as a whole. For details, please see Table 1.

Science

Many science experiments benefit from the use of NIST's synchrotron facility. NIST's research has influenced inventions such as gas lasers, methods of cooling and trapping atoms with laser light, and the Topografiner (see Table 2).

Consumers

Consumers benefit daily from NIST's work on measurements—examples include fairness in the marketplace owing to trusted weight and volume measurements, accurate radiation doses for diagnosis

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Table 1. NIST contributions to industry (see www.nist.gov/centennial/industry.cfm).

Contribution	Industry/technology affected
Standard of Frequency (1923)—clearer signals Broadcasting precise frequency signals	Radio and television, power and telephone, and financial institutions
Liquefied helium (1931)—a coolant used, for example, in magnetic resonance imaging	Aerospace, medicine, and manufacturing
First Federal Government cryptographic algorithm First Data Encryption Standard (1977) Development of powerful successor standard	Financial services, telecommunications, and hardware and software
Photomask linewidth standard (1979) Rulers for measuring widths of integrated circuit features New measurement approaches	Semiconductors and direct counting of atoms
Meeting of State weights and measures officials (1905) National Conference on Weights and Measures	Fair marketplace
Manufacturing Extension Partnership (MEP) (since 1989)—goal reached in 1996	Small manufacturing firms
Refrigerant property data (more than 50 years) Database of the thermophysical properties of alternative refrigerants (1989)	Air conditioning and refrigeration
DNA chips	Medicine
Standard for ballistic resistance of police body armor (since 1970s)	Bullet-resistant armor
Forensic work (since early 1900s)	Law enforcement
Baldrige Criteria for Performance Excellence (since 1987)	Quality improvements and competitiveness

Table 2. NIST contributions to science (see www.nist.gov/centennial/science.cfm).

Contribution	Field/research area affected
Atomic Energy Levels volumes (1949–1958)—models of authenticated, verified, and consistent spectroscopic data Spectroscopy research	Laser pioneers and the invention of gas lasers
Experiments using synchrotron light (1961) Synchrotrons—facilities that produce a unique type of radiation	Astrophysics, medicine, and microelectronics
Handbook of Mathematical Functions (Dover Publications, 1964)	Many science fields
Joint experiment using laser reflectors on lunar surface	Distance between Earth and moon
World-record measurement of frequency of laser light	More accurate value for the speed of light and a more stable definition of the meter
Methods of cooling and trapping atoms with laser light New state of matter (1995) William D. Phillips' Nobel prize (1997)	Physics
Materials research	New explanation on Titanic sinking
Forerunner of scanning tunneling microscope (1971)	Molecular biology and nanotechnology
Topografiner—novel microscope for surveying surfaces in great detail	Surface science

and treatment, and precise time synchronization through highly accurate atomic clocks. NIST's investigations and standards also help protect us from structural collapses and fire risks (see Table 3).

Technology

NIST's developments have led to today's air traffic control, weather forecasting, and smart weapons systems, as well as to the development of cryogenic refrigerators (see Table 4).

National Security

NIST contributed to the US aviation modernization, the atomic bomb creation, electronics miniaturization, and the smart weapon systems design (see Table 5).

Table 3. NIST contributions to consumers (see www.nist.gov/centennial/consumer.cfm).

Contribution	Consumer use
Radiation measurement and standards (since the 1970s) Help with the 1931 X-ray safety code	Safe medical use of radiation
Research with American Dental Association: Hydraulic turbine dental hand piece (1953), the panoramic X-ray machine, composite filling materials, and dental adhesives	Dental treatment
Accuracy and uniformity in weights and measures (since 1905)	Precise food labels
Standard Reference Materials (SRMs)—artifacts with certifiable measurements or properties—for clinical applications (since 1967)	Accurate and reliable laboratory tests—blood cholesterol levels, DNA fingerprinting, and so on
Investigations of structural failures (1967 collapse of Point Pleasant Bridge, 1981 collapse of walkways in Hyatt Regency Hotel, 2001 collapse of World Trade Center)	Designs, materials, and procedures to enhance safety of structures
First publicly available data encryption standard (1977) and Advanced Encryption Standard (2001)	Securing electronic data transactions
Help with first fire performance standard for smoke detectors and recommendations on number, type, and placement	Fire prevention
Standards for voltmeters calibration (technology developed in 1980s)	Compact disc players

Table 4. NIST contributions to technology (see www.nist.gov/centennial/technology.cfm).

Contribution	Technology use
First "visual type" radio beacon—instrument landing system Radio technologies for sea and air navigation	Air traffic control systems and sea navigation
Radiosonde—balloon-borne instrument (1936)	Weather forecasting
First atomic clock—based on ammonia molecule (1949) Latest atomic clock neither gains nor loses a second in nearly 20 million years	GPS and other communications and navigation technologies
Cryogenics research (over a century)—production and effects of very low temperatures	Scientific, military, aerospace, industrial, and medical fields
First operational, internally programmed digital computer in the US with graphical display (1950) First scanner and first computerized image (1957)	IT—Standards Eastern Automatic Computer
New standard for the volt—based on a single, simple equation—more accurate, stable, and easier to use	Physics

In this Issue

The articles in this special issue focus on NIST's recent contributions in the areas of test generation, search engines, select cybersecurity technologies, and biometrics.

NIST's work on automatic tests generation since 1998 has evolved into a broad area known as *model-based testing*. NIST's technology has been the basis for the advances in model-based testing worldwide and was also modified to measure the coverage of test suites independent of implementation details. With several commercial tools incorporating model-based test generation, NIST's work laid the foundation for widely used techniques. The first article, "Test Generation Using Model Checking and Specification Mutation," by Paul E. Black, discusses NIST's relation to computer science, recent work in software testing, and model-based testing and its impact today.

The second article is "Building Better Search Engines by Measuring Search Quality," by Ellen Voorhees, Paul Over, and Ian Soboroff. It presents the NIST Text Retrieval Conference (TREC) project, which has been instrumental for more than 20 years in creating the infrastructure to measure quality of search results. The discussion is on the origins of TREC; community evaluations; and the developments in the project tracks on filtering, question answering, e-discovery, and video analysis. TREC has helped fuel the recent explosive growth in search-related technologies.

The next article, "NIST and Computer Security," by William Burr, Hildegard Ferraiolo, and David Waltermire, presents four computer and

Table 5. NIST contributions to national security (see www.nist.gov/centennial/security.cfm).

Contribution	Security-related field/technology affected
Testing, modification, and overhauling of aviation instruments Quantitative data on power-producing qualities of fuels Studies of flight aerodynamics	Aviation (including military aviation)
Central control lab on properties of uranium Purity of critical materials in nuclear reactors and bombs	Atomic bomb (WWII), nuclear reactors and bombs, and Military's Manhattan Project
Radio direction finder—antenna determining direction of radio transmissions Simple effective submarine radio apparatus—proving radio communication is not impossible under water	Navy (WWI)
Weapons research leading to the development of printed circuits	Miniaturization of electronics
Thermodynamics of rubber Standardized physical and chemical testing	WWII rationing of natural rubber, accuracy in rubber testing, and synthetic rubber plants
Radio proximity fuse—explodes projectile directly over its target, rather than on impact The Bat—the first fully automated guided missile	WWII early "smart" weapons systems
Antennas testing on communication to and from satellites Theory of the complex outdoor radiation pattern of antennas	Military
Standards for voltmeters calibration (technology since 1980s)	Missile guidance systems
Real-time control system—for controlling automation	Precision of shipbuilding and clearing of land mines

information security areas in which NIST has significant impact. The areas are cryptographic standards, role-based access control, identification card standards, and security automation (security content automation protocol, and the national vulnerability database). Original NIST research in these areas has led to the development of technologies that have become industry standards and the basis for IT industry products. For example, NIST cryptographic standards are used in banking and electronic commerce and are built into operating systems and communication protocols.

The final article, "NIST Contributions to Biometric Technology," by Brad Wing, presents NIST contributions to IT applications for biometrics and identity management. For almost 50 years, NIST's work has included the development of hardware and software for automated analysis of fingerprint images; voice recognition capabilities; datasets and testing procedures for performance evaluation of algorithms and equipment; and methods for conducting evaluations using sequestered data. The article discusses NIST's role in the advancement of biometric technology, focusing on research, product and algorithm evaluation, and standardization and best practice guidelines.

For IT professionals, it's important to know about NIST's significant contributions to the world of science and technology, industry, the economy, and the general public. These four articles, as well as this issue's Spotlight department, provide a snapshot of NIST's accomplishments in IT. Furthermore, NIST's Information Technology Laboratory (www.nist.gov/itl) has a diverse set of ongoing and future projects that should be of interest to IT professionals.

References

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