



Key Challenges facing Government and Industry in Pipeline R&D: A Standards View

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NIST**

**Government/Industry Pipeline R&D Forum
Houston, Texas
March 22-24, 2005**

National Institute of Standards & Technology

NIST's mission is to develop and promote measurement, standards, and technology to enhance productivity, facilitate trade, and improve the quality of life.

NIST Assets Include:

- 3,000 employees
- 1,600 associates
- \$771 million FY 2004 operating budget
- NIST Laboratories -- National measurement standards
- Advanced Technology Program
- Manufacturing Extension Partnership
- Baldrige National Quality Award



The mission drives the measures

Goal: Provide technical leadership for the Nation's measurement and standards infrastructure, and assure the availability of essential reference data and measurement capabilities.

Basic Units

Maintained by NIST

- Time • Length • Mass • Temperature
- Electric Current • Light intensity
- Angle • Amount of Substance (mole)

Derived Units

Maintained by NIST

- Frequency • Diameter • Volume
- Acceleration • Density • Force
- Pressure • Voltage • Radiation

Standards & Calibrations

Traceable to NIST

- Global Time Service
- Laser frequency • Gage blocks
- Line standards • Radioactivity
- Electrical quantities
- Reference materials

Applications

- Telecommunications
- Computer "chips"
- Pharmaceuticals
- Medical imagers
- Gasoline pumps
- Digital clocks
- TV Signals
- CD-Roms
- Aircraft...



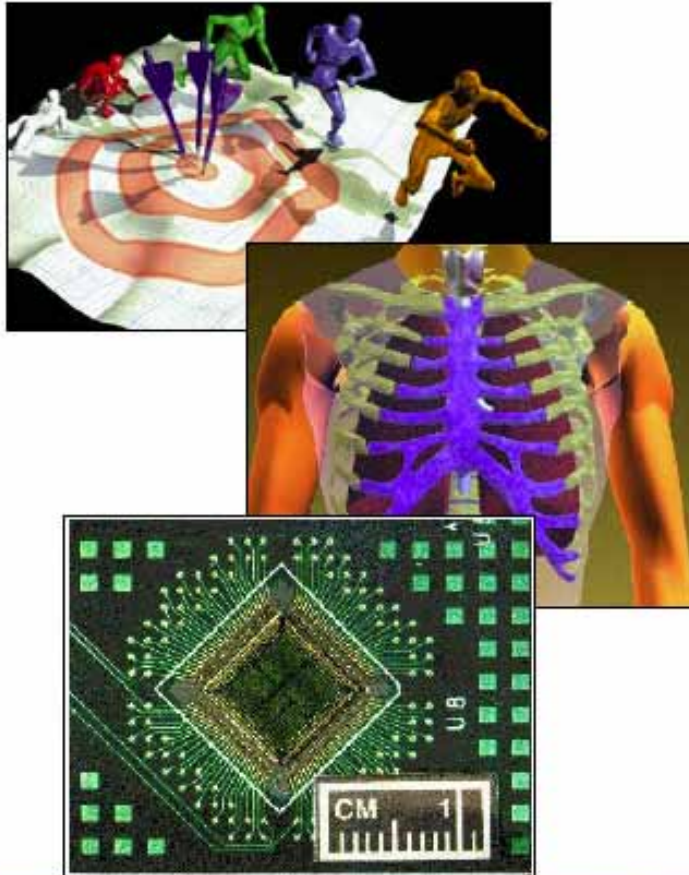
LEVERAGE

Approx. \$500 M/yr NIST investment (0.7% of federal R&D)

Undergirds ~\$10 B/yr of private sector investment in measurements and standards

Impacts U.S. economy - quality and productivity of R&D; reduced transaction costs; greater economic efficiency; higher quality health and safety

NIST Advanced Technology Program



- Co-funding of private sector R&D to accelerate the development of high-risk, broadly enabling technologies.
- Auto Body Consortium - improved fitting of parts to save money for manufacturers and consumers
- Tissue Engineering - new materials to repair damaged ligaments and tendons: several billion dollar impact
- "DNA Chips" - new technology for cheap, rapid genetic analysis

NIST Research and Services Integral to a Competitive, Productive Economy

Embedded Tools Essential to Commerce, Industry

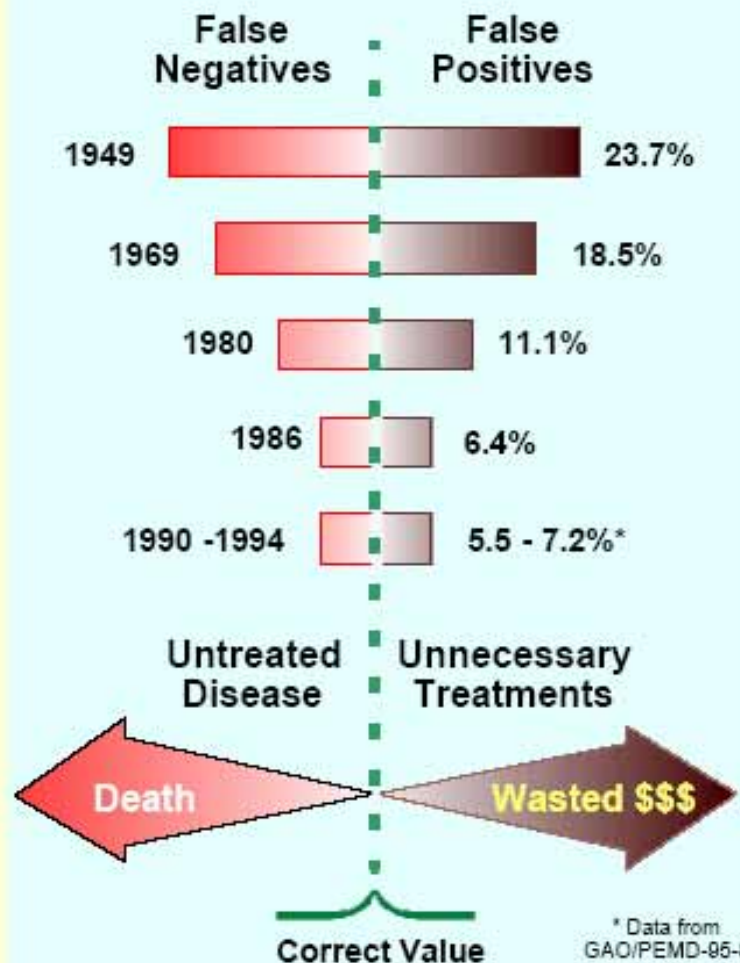
- **Consumer Trust**—ultimate references for \$5 trillion in annual sales based on measurement
- **Secure Automated Banking**—encryption technology embedded in nation's 300,000+ ATMs
- **Integrity of Financial Transactions**—time-stamping of stock trades, etc., totaling hundreds of billions of dollars daily
- **Manufacturing Quality Control**—U.S. automakers and suppliers rely on 350 NIST reference materials
- **Reliable Data**—more than 53,000 volumes of NIST/ACERS "phase diagrams" distributed to materials researchers & manufacturers

Impacts are project specific

NIST Contributions to National Reference System for Cholesterol

- 1967 - SRM 911 Pure Cholesterol
- 1980 - Definitive Method for Serum Cholesterol
- 1981 - SRM 909 Cholesterol in Human Serum
- 1988 - SRMs 1951 & 1952 Cholesterol in Serum
- 1996-7 - Values for HDL & LDL Cholesterol

Measurement Improvement 1969 - Present
May Save \$100M/year in Treatment Costs



NIST Research and Services Underpin Homeland Security, Public Safety

Critical Technical Contributions

- Standards for Ballistic-Resistant Armor—*2,700 Casualties Prevented*
- Advanced Encryption Standard—*Secure electronic transactions for millions of Americans*
- Standards for Metal Detectors—*Improved safety in airports, courthouses*
- Standards for DNA analyses—*Accuracy goes up, costs go down*
- Interoperability Standards for Fingerprint Databases—*FBI system can link to the rest of the world*

Programs Guided by Stakeholder Roadmaps and Needs Assessment



Semiconductor Industry Association

Optoelectronics Industry Development Association

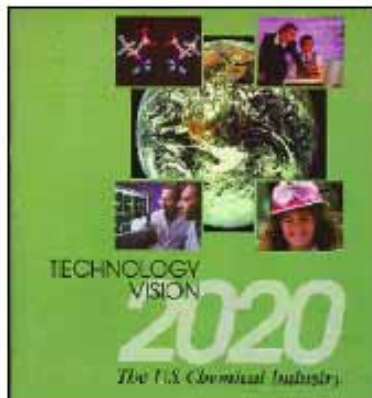


Multiple Roadmaps

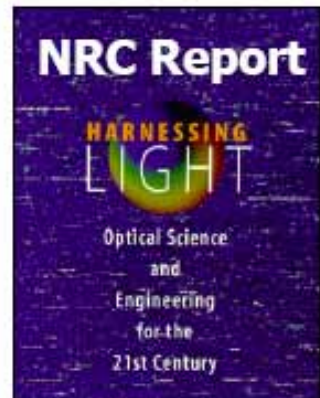
President's Information Technology Advisory Committee



Roadmap



Chemical industry vision/roadmap



Optics needs



National Bureau of Standards: Corrosion of Buried Pipe



Alexandria, VA 1922



H. K. Logan

Original Burials Started in 1922

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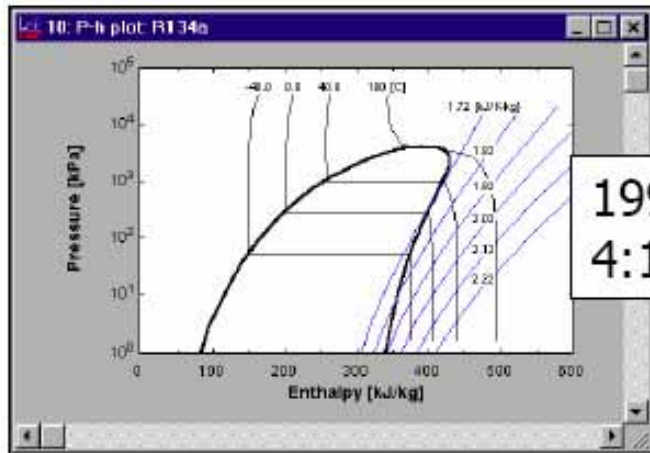
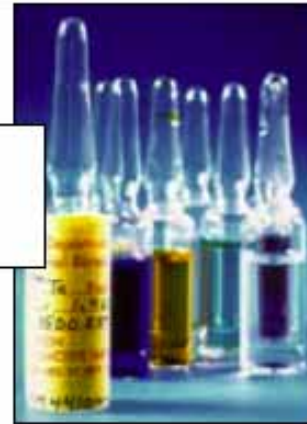
NIST Measurements, Standards, and Data to ensure Pipeline Integrity: PSIA 2002

- Materials performance and reliability
- Engineered fire safety for people, products, and facilities
- Fire fighter safety and effectiveness
- Critical Infrastructure Protection: cyber security of industrial control systems (SCADA)



Economic Impact Assessment Studies

1997: Radiopharmaceutical standards
97:1 benefit-to-cost ratio



1998: Alternative refrigerants
4:1 benefit-to-cost ratio

2000: Sulfur in fossil fuels
113:1 benefit-to-cost ratio



Programs Guided by Stakeholder Roadmaps and Needs Assessment



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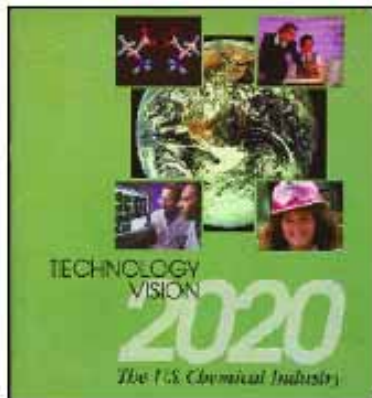
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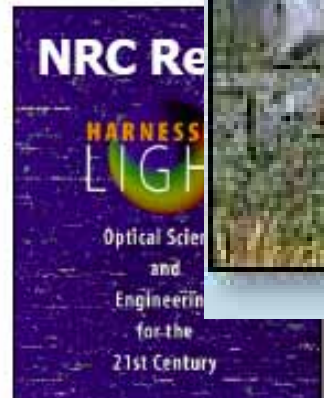
Industry Roadmaps



Process Roadmaps



Chemical industry vision/roadmap



Optics needs





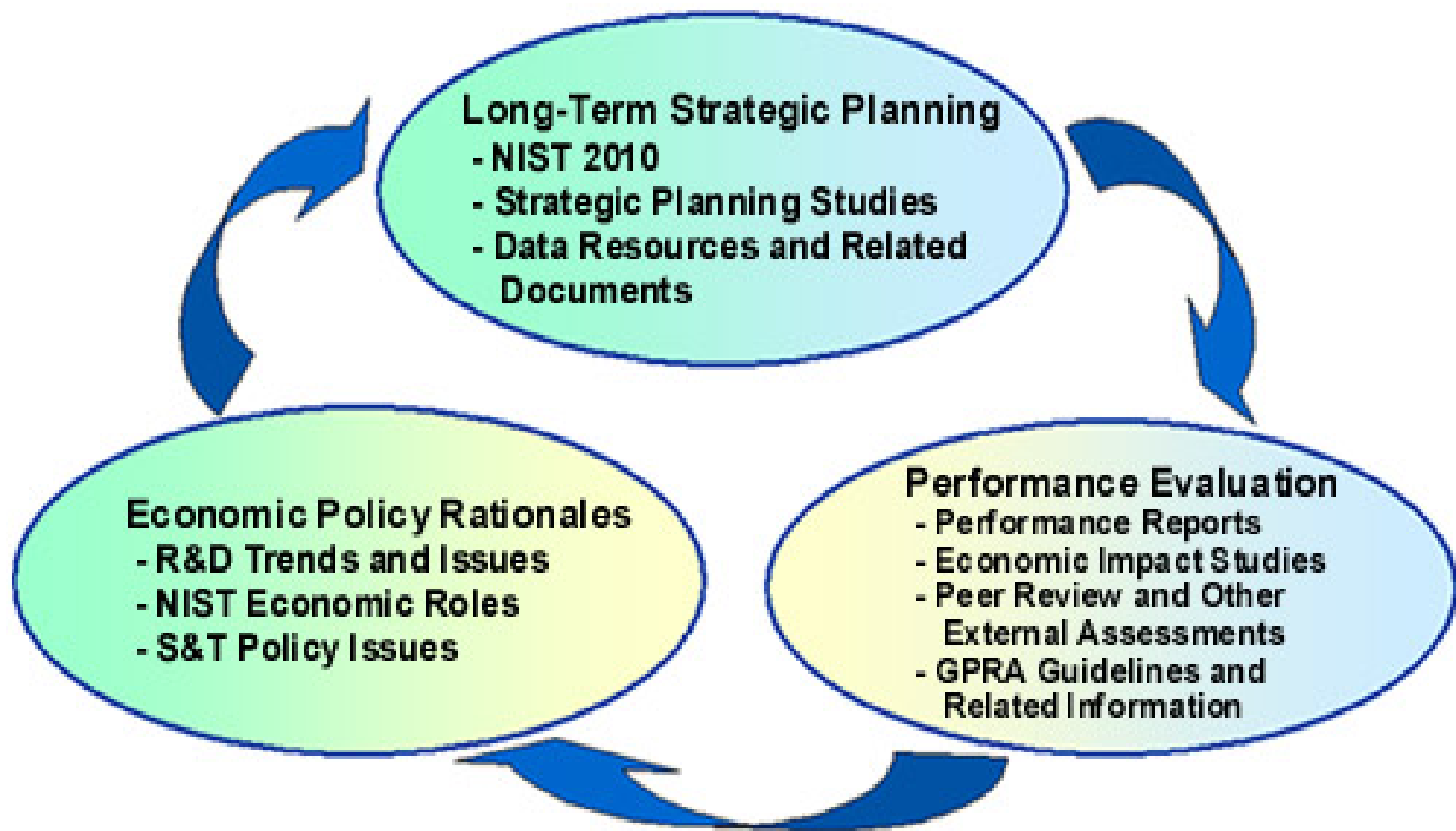
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Strategic Planning: NIST 2010

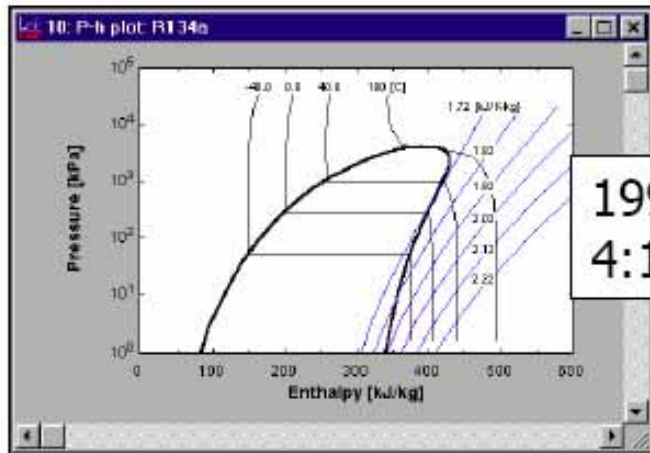
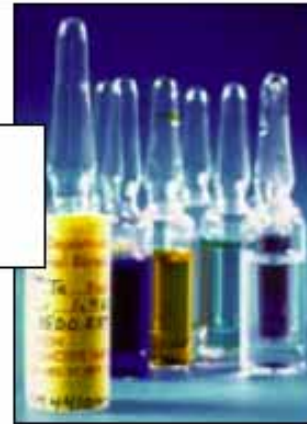


- **Provides a process for long-term planning**
- **Covers all of NIST**
- **Responds to strategic environment**
- **Ensure preeminent performance**



Economic Impact Assessment Studies

1997: Radiopharmaceutical standards
97:1 benefit-to-cost ratio

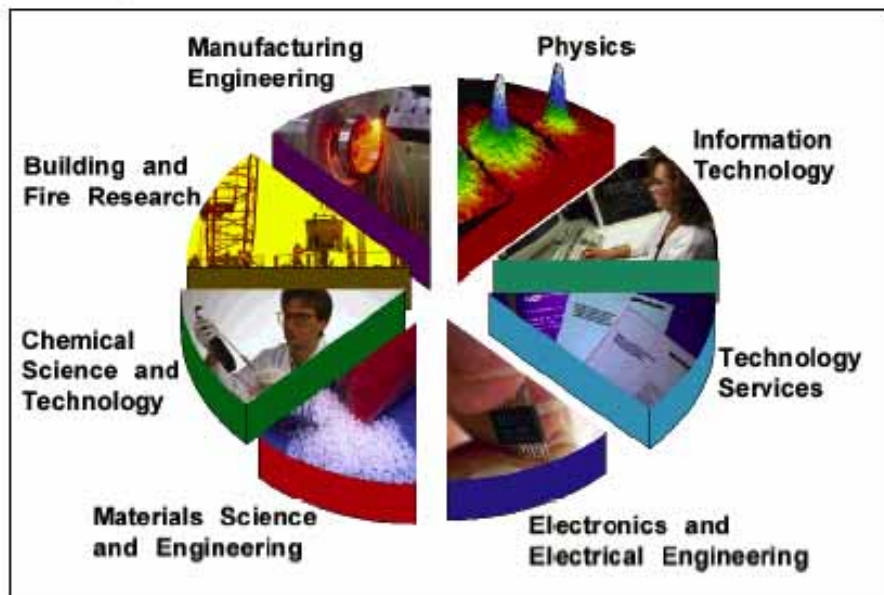


1998: Alternative refrigerants
4:1 benefit-to-cost ratio

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NIST Laboratories



NIST's work enables

- Science
- Technology innovation
- Trade
- Public benefit

NIST works with

- Industry
- Academia
- Other agencies
- Government agencies
- Measurement laboratories
- Standards organizations

NIST Laboratories Products and Services

- **Measurement Research**

2,100 publications/year

- **Standard Reference Data**

90 types available

5,000 units sold/ year

- **Standard Reference Materials**

>1,200 products available

30,000 units sold/year

- **Calibrations and Tests**

3,200 items calibrated/year

- **Laboratory Accreditation**

826 accreditations

- **Standards Committees**

390 NIST staff, 450 committees

NIST Advanced Technology Program

Exciting New Technologies....



***Bridging the Gap Between the
Laboratory and the Marketplace***

NIST Research and Services Vital to Quality of Life

Practical, Indispensable Technical Contributions

- Diagnostic X Rays—*Standards & tests underpin 30 million mammograms performed each year*
- Prostate- and Breast-Cancer Treatment—*Among 10 million medical procedures using radioactive materials traceable to NIST measurements*
- Smoke Detectors—*Performance standards for devices now in 94% of U.S. homes*
- Drinking-Water Quality—*Accreditation enables 55,000 community water systems to check, prove regulatory compliance*

NIST Research and Services

Enabling Innovation

- Paving the Way for Economic Growth
- “Excellence in measurement science, driven by NIST, positions U.S. industry and universities to more quickly solve problems.”—IRI
- “Consequently, additional research in metrology at NIST is critical to future chip development.”—SIA
- “NIST stimulates and supports the development of the cutting-edge technology infrastructure needed to strengthen and safeguard America’s economic foundations and security capabilities.”—BIO

NIST Materials Performance Programs

MSEL

Measurements, modeling, standards:

- Mechanical behavior of materials in service: metals, ceramics, polymers, composites, coatings
- Mechanical properties: impact strength, hardness
- Nondestructive examination
- Welding
- Fracture mechanics and failure analysis – crack arrest

NIST Role:

Integrated, authoritative,
multi-disciplinary teams

Providing assistance to

Department of Transportation
Department of Energy
Department of Defense
Nuclear Regulatory Commission
NASA, FEMA, ...

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Materials Performance and Reliability: Extreme Exposure Conditions

- Recent unfortunate events suggest that pipelines and facilities may be subjected to:
 - **High velocity impact**
 - **Explosion**
 - **Fire**
 - **Fire followed by detonation**
 - **Cyber failure or attack**
- What is appropriate research to predict pipeline behavior and assure integrity for range of conditions, including LNG facilities and low temperature service?

NIST Facilities and Research Relevant to Pipeline Integrity

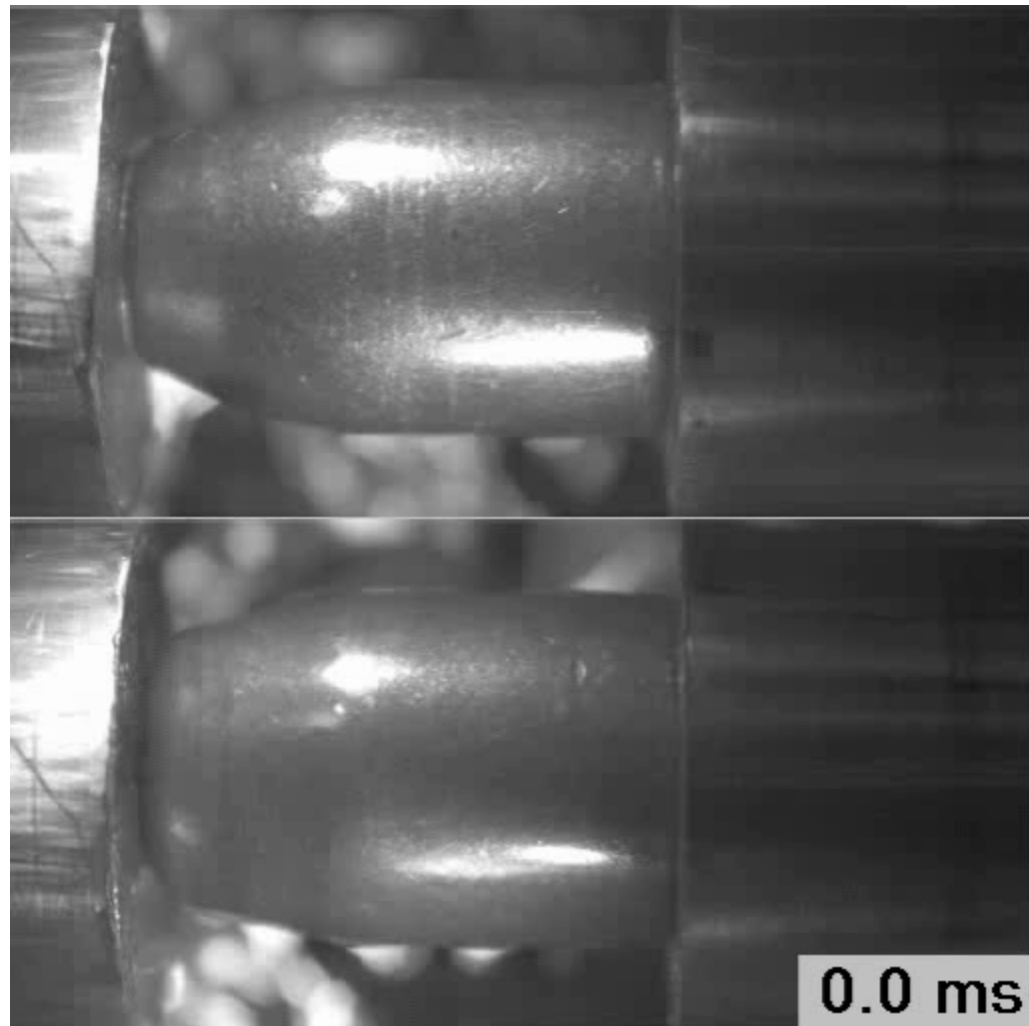
- **Impact by projectiles, etc.**
 - High rate/dynamic Stress-Strain Behavior of Linepipe Steels
 - High rate/dynamic Behavior of Projectile Materials
- **Explosions**
 - High rate/dynamic Stress-Strain Behavior of Linepipe Steels
 - Dynamic Toughness of Linepipe Steels

NIST Facilities and Research Relevant to Pipeline Integrity (cont.)

- **Fires**
 - High temperature mechanical properties of linepipe steels
 - Stress-strain behavior
 - Short term time-dependent (creep) behavior
- **Fires and Detonations**
 - All of the above and High Temperature Dynamic Toughness

NIST investigating behavior of projectiles that might be used to compromise integrity

Very high rates can be studied at NIST Kolsky Bar Facility



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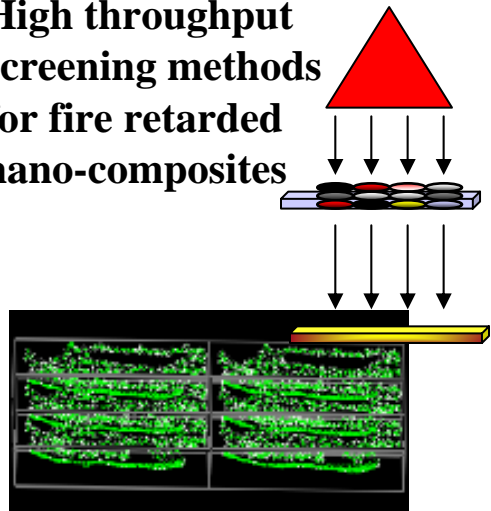
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Strategy to Reduce Fire Losses

Reduce *residential fire deaths, injuries and property losses* by

- adapting measurement and predictive methods to better understand conditions leading to *flashover*,
- enabling early and certain fire and environment sensing,
- advancing cost-effective fire suppression technologies; and
- enabling new/improved materials whose fire resistance does not negatively impact performance, cost, or the environment.

High throughput
screening methods
for fire retarded
nano-composites



Home smoke alarm evaluation



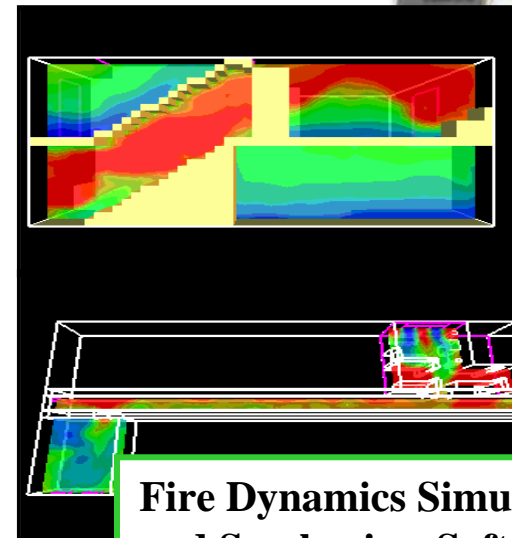
Strategy to Reduce Fire Losses

Reduce *fire fighter line-of-service deaths and burn injuries* by

- providing new *technology*, measurement standards, and training tools;
- enabling shift to an information rich environment.



Fire scene knowledge-enhancement



Fire Dynamics Simulator and Smokeview Software used to analyze fire events, firefighter training

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National Building and Fire Safety Investigation of the World Trade Center Disaster

- **Task 2 – Document failure mechanisms and damage**

- **Contractor visual inspection of steel and analysis of failures completed; report drafted**

- **Extensive analysis by NIST of steel**

- failure mechanisms analyzed and documented

- repeated patterns of fracture/failure analyzed

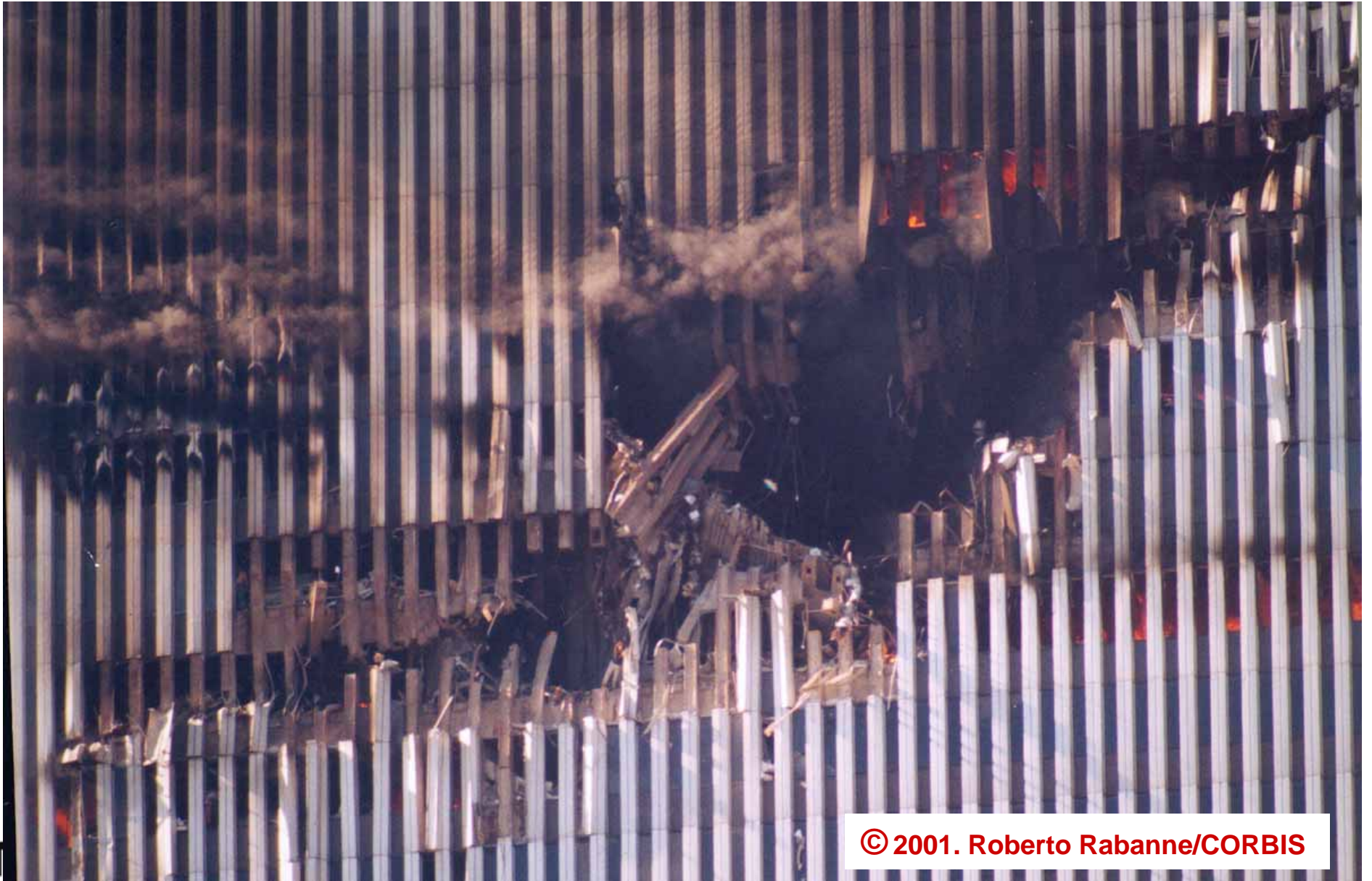
- failures mapped on structure

- **Photographic evidence enhanced and compared with recovered steel.**

- ***Report being drafted***



Original Image – North Tower, North Face



© 2001. Roberto Rabanne/CORBIS

Processed Image



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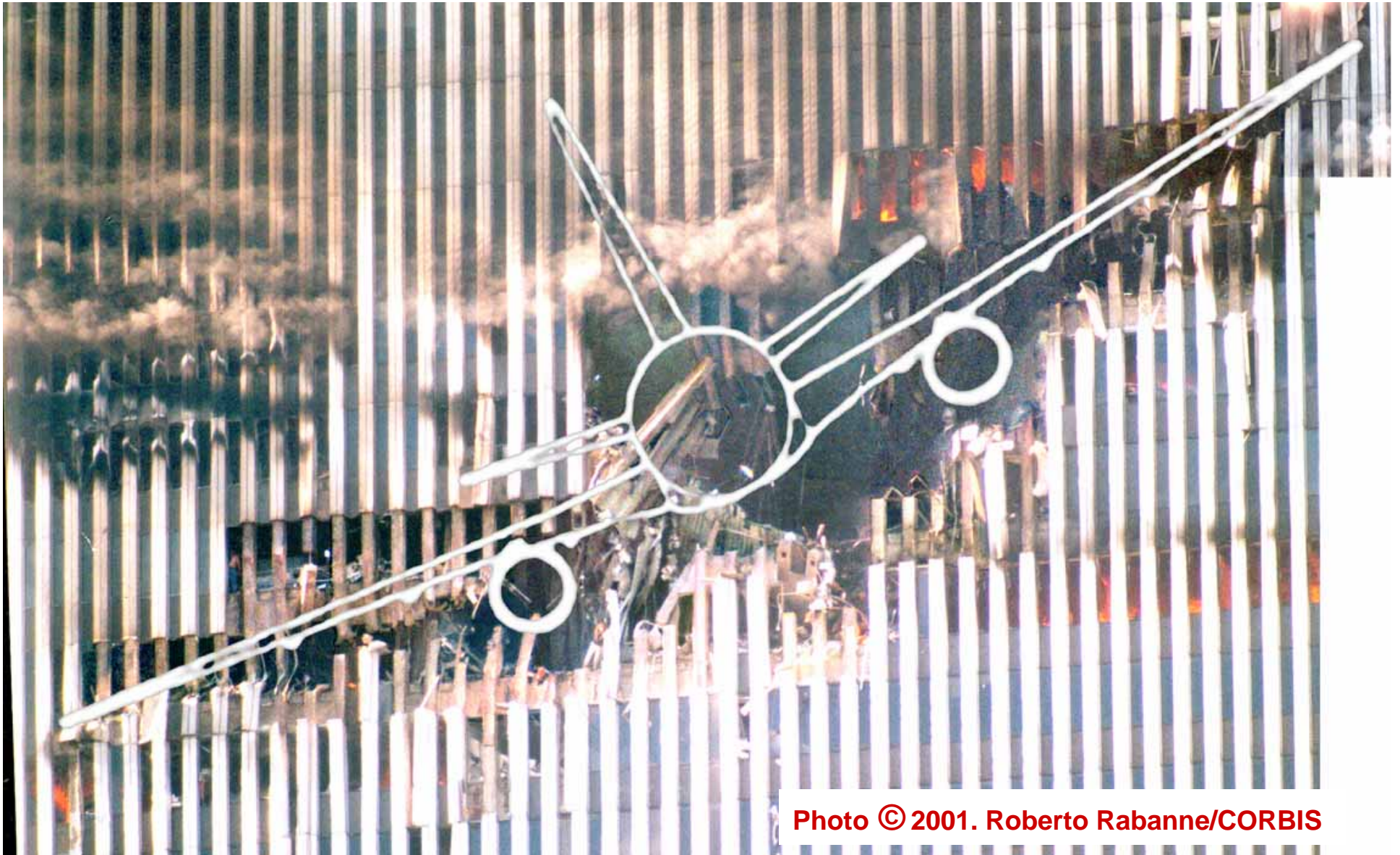


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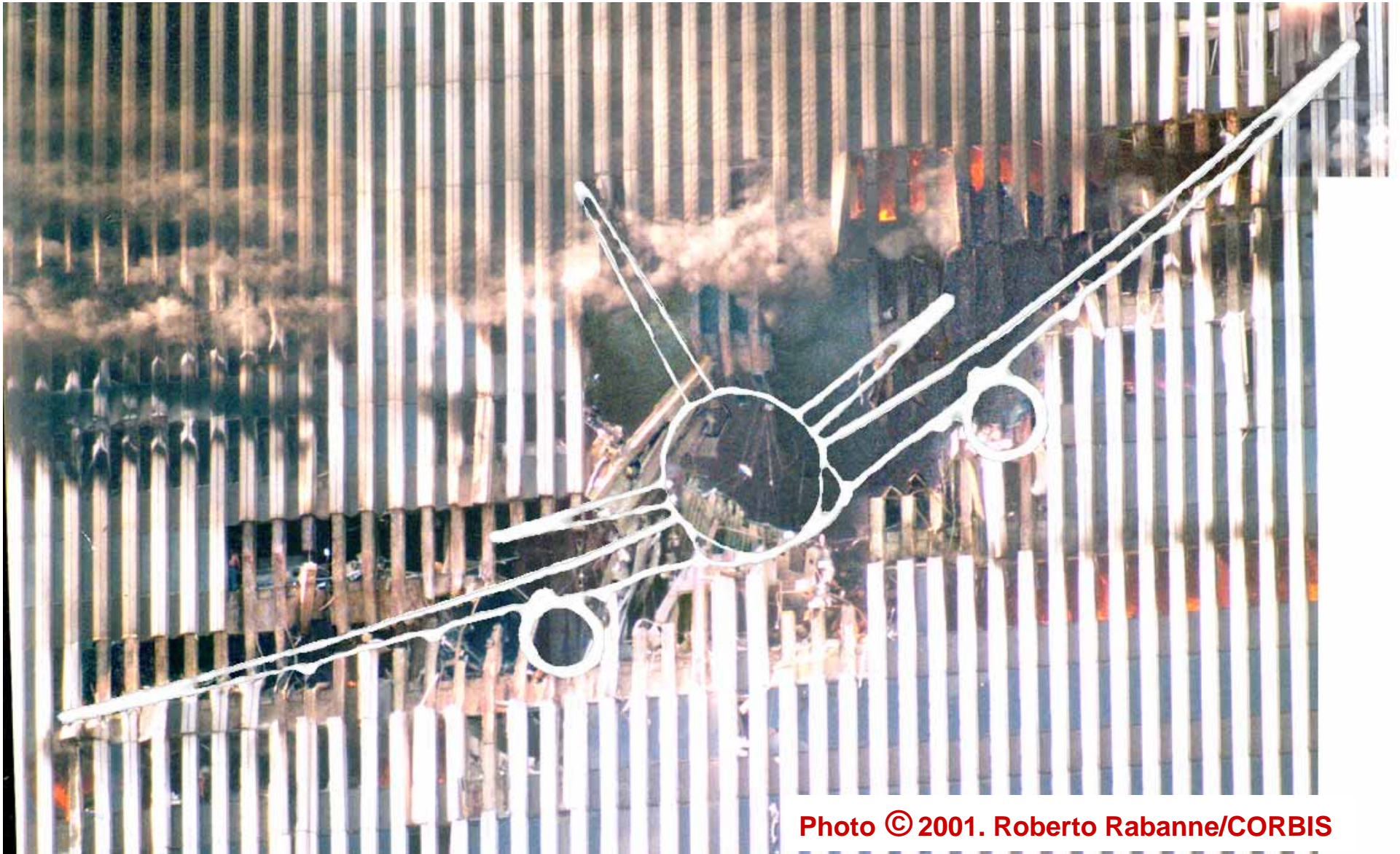


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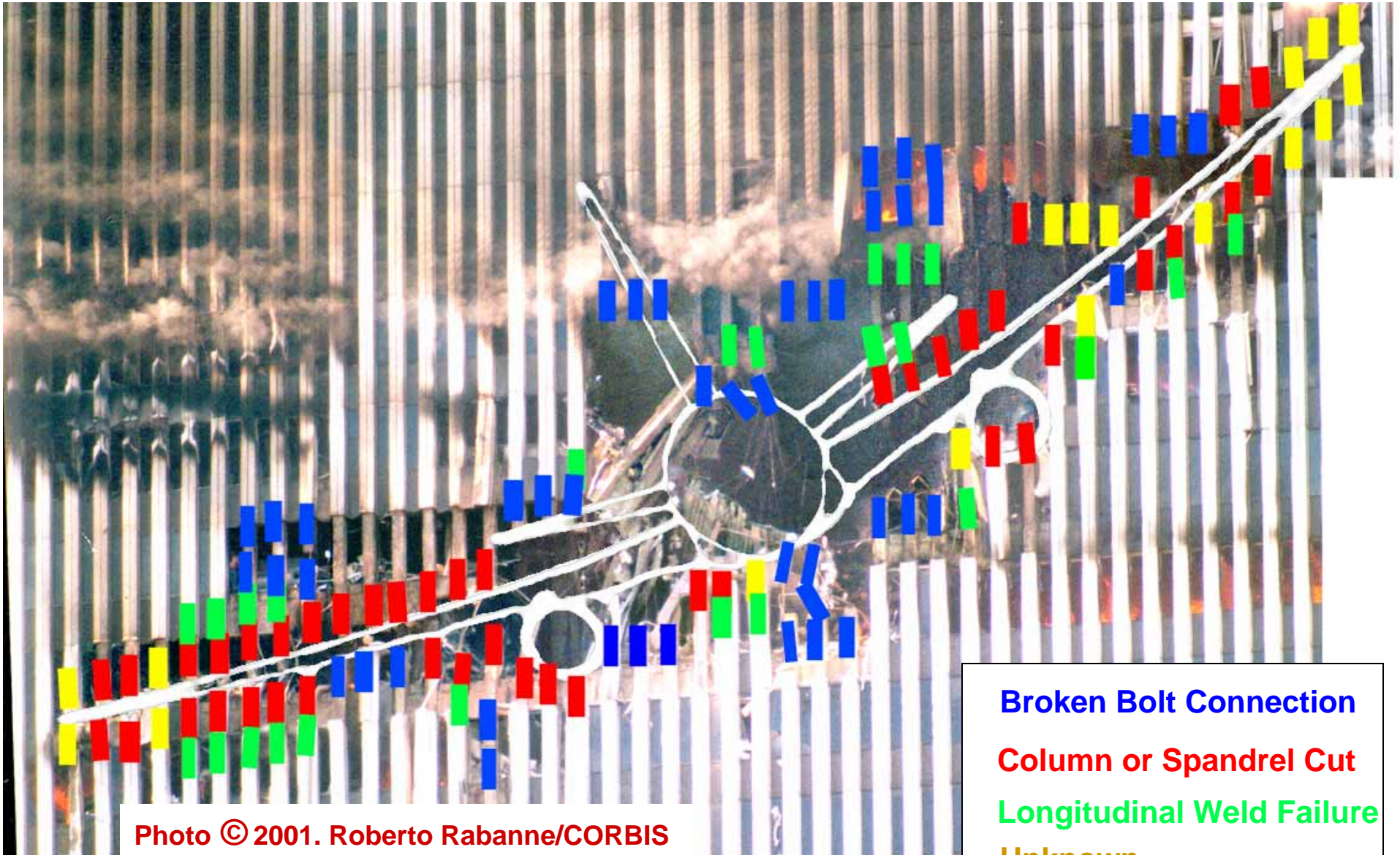


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Broken Bolt Connection
Column or Spandrel Cut
Longitudinal Weld Failure
Unknown

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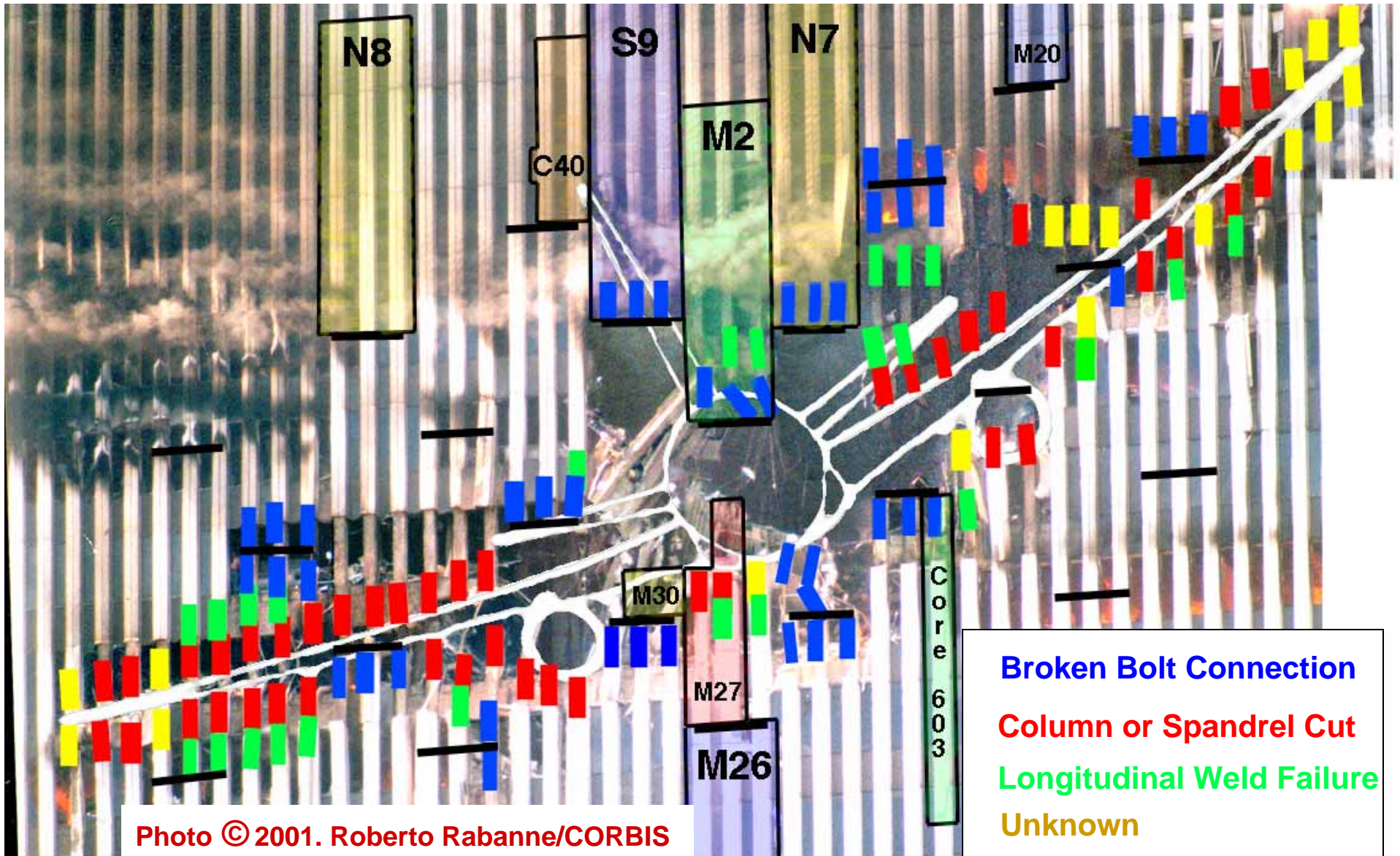


Photo © 2001. Roberto Rabanne/CORBIS

- Broken Bolt Connection
- Column or Spandrel Cut
- Longitudinal Weld Failure
- Unknown
- Panel Junction

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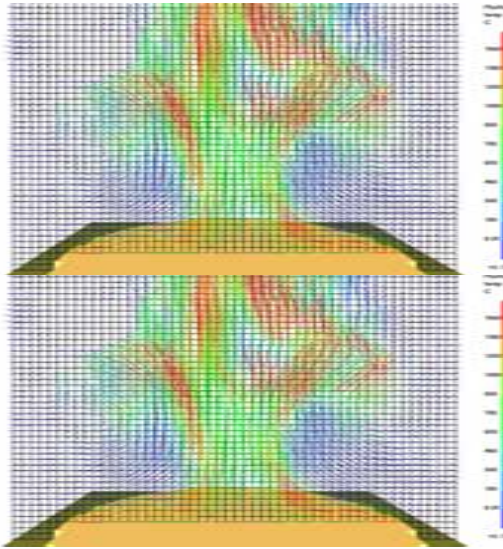
➤ *Material properties have been supplied for:*

- *all structural steels (29 steels), bolts, and welds*
- *thermal expansion, thermal conductivity, elastic, plastic, creep,... as function of stress, temperature, and time*

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Pool Fire Simulations



Large-scale



Small-scale



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NIST Strengths Related to Pipeline Safety



- Large-scale fire experiments and measurements
- Simulating gas and liquid fuel sprays at all scales
- Simulating jet fires, pool fires and buoyant smoke plumes
- Simulating building/wildland fires
- Linking models of vastly different length scales
- Predicting/measuring thermal radiation, and smoke and aerosol characteristics
- Training first responders

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Critical Infrastructure Protection: Cybersecurity

- **The (US) National Plan for Information Systems Protection and other reports cite industrial control systems as critical points of vulnerability in America's utilities and industrial infrastructure...**

**Electric power — Water — Oil & Gas
Chemicals — Pharmaceuticals
Mining, Minerals & Metals
Pulp & Paper — Food & Beverage
Consumer Products
Discrete Manufacturing
(automotive, aerospace,
durable goods)**



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NIST Program on Critical Infrastructure Protection: Cyber and SCADA

- **Long-term Objective:** Integrate security engineering into the industrial automation life cycle, including design, implementation, configuration, maintenance and decommissioning
- **Outcome:** Reduced likelihood of successful cyberattack on the nation's critical infrastructure
- **NIST Role:** Work with industry to develop standards and test methods for validation and conformance



Process Control Security Requirements Forum (PCSRF)

Immediate Goal:

Increase the security of industrial process control systems through the definition and application of a common set of information security requirements for these systems.

Based on NIST and NSA work
to develop the *ISO 15408*
Common Criteria for IT Security
Evaluation



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PCSRF Website

<http://www.isd.mel.nist.gov/projects/processcontrol>



The screenshot shows a web browser window displaying the PCSRf website. The browser's address bar shows the URL <http://www.isd.mel.nist.gov/projects/processcontrol>. The website header features the text "Manufacturing Engineering Laboratory" and "ISD's Research Areas" on the left, and the "NIST National Institute of Standards and Technology" logo on the right. A navigation menu below the header includes links for "ISD Home", "About ISD", "Research Areas", "Products and Services", "What's New", and "Search". The main content area is titled "Process Control Security Requirements Forum (PCSRF)" in purple. Below the title are two images: the left one shows an industrial facility with several tall smokestacks, and the right one shows a power transmission tower against a sunset sky. The text "Welcome" is displayed in purple. The main body of text explains that the site is a resource for users, vendors, and third parties in the process control industry, and that it supports the development of standards for process control security through the NIST initiative on Critical Infrastructure Protection (CIP). It mentions the establishment of the PCSRf as a working group applying the ISO 15408 Common Criteria methodology. A note at the bottom states that all information on the site is now password protected and provides a link to request a password. At the bottom of the page, there are two columns of purple links: "Join the PCSRf", "Upcoming Meetings", "Documents", "Participants", "What's New", "Meeting Minutes and Reports", "Resources and Links", and "Mailing List Information". The browser's status bar at the bottom indicates "Document: Done (0.391 secs)".

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- Engineered fire safety for people, products, and facilities
- Fire fighter safety and effectiveness
- Critical Infrastructure Protection: cyber security of industrial control systems

