Presentation to: Buildings for Advanced Technology Workshop – NIST
January 14-16 2003

Science Needs for High Performance Laboratories

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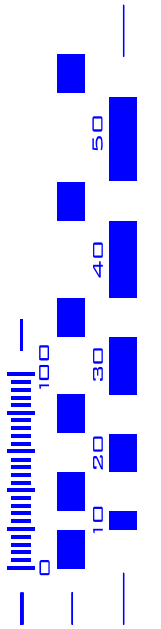
January 2003



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NPL Core Mission

- to identify and meet our customers' current and future requirements for standards, measurements and services;
- **to undertake and apply leading-edge research in measurement science and technology;**
- to support the international system of measurement in collaboration with other national measurement institutes;
- to create, disseminate and apply expert knowledge to enhance industrial competitiveness and quality of life;
- to operate with exemplary efficiency, delivering demonstrable value to industry, government and society;
- to provide an inspiring and rewarding working environment; and
- to promote the importance and relevance of what we do

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Rigorous Approach to Choices and Priorities

- The strategic concept and process – HAX[1]
- Used by top 100 UK corporations
- Actual experience
- Methodology adapted for an NMI

[1] "The Strategy Concept and Process – A Pragmatic Approach"
By Arnaldo C Hax and Nicholas S Majluf, published by Prentice Hall, 1996

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Process

NPL Vision

A World-leading measurement science laboratory, globally recognised for excellence; uniquely positioned to forge links between scientific, commercial and government communities.

NPL Internal Scrutiny

- the NPL Mission
- business scope
- identification of unique competencies
- critical success factors
- competitive position
- values

Definition of strengths and weaknesses

NPL Environmental Scan

Analysis of:
- critical customer and market sectors
- scientific environment
- political, regulatory and other trends
- economic outlook

Identification of opportunities and threats

NPL Strategy	Strategic Thrusts Performance Metrics
Resource Allocation	Portfolio Management
Managerial Infrastructure	Organisational Structure Business Systems and Processes
Human Resources	Selection, promotion and motivation of Key Personnel

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Strategic Thrusts

- HR Development
  - Performance management / development processes
  - Recognise and Reward performance
  - Internal communications
- **Scientific Excellence**
  - Science strategy to support the Vision
  - Consider new / emerging fields
  - Exit selected areas
- Profitable growth
  - Business development process
  - Knowledge transfer
- Operational excellence
  - New business information system
  - Service delivery
- Relationship management
  - External communications
  - alliances

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Scientific Excellence

Implement a Science Strategy to support the Vision, considering entry into new and emerging fields and withdrawal from others

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Process

- Define procedure and assessment criteria (Science Strategy Group)
- Define and obtain inputs/data for assessment of priority
- Conduct prioritisation assessment exercise
- Assign priorities to scientific areas
- Consult with NPL Fellows, Centres and DTI
- Develop a plan for action
- Prepare implementation plan
- Monitor progress

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Key Considerations

- How to segment NPL's activity into science areas?
  - DTI programmes / science
  - Other developments – Research Councils / Government / EC
- How do we measure science attractiveness?
  - Measurement relevance
  - National Metrology Institute context
  - Quality of life
  - Industrial competitiveness
- How do we assess internal strengths?
- How do we balance our commercial needs against National Infrastructure needs?

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Science Areas

- Nanoscience
- Photonics
- Biotechnology
- Applied Optics
- Acoustics
- Mathematical Modelling / Inf Science
- Electrical Measurement
- Structural Materials
- Quantum Metrology
- Physical & Chemical Thermodynamics
- Nuclear Physics & Ionising Radiation
- Functional Materials
- Environmental and Oceanic Science
- Mechanical Sciences

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Prioritisation Criteria

Categories

Attractiveness

Measurement relevance

Scientific and technical momentum

NMI dimension

Scientific recognition potential

Technological growth potential

Internal Strength

Scientific Staff

Scientific and technical output

Scientific capital facilities

Scientific synergy

Competitive intensity

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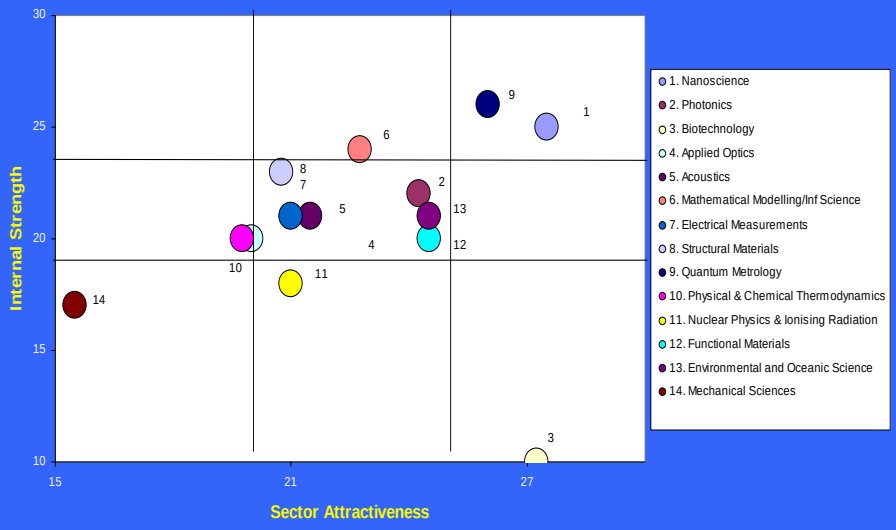
Science Strategy Scoring



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Priority Areas of Research

The six Priority Areas of research for NPL were identified as:

- Nanoscience
- Biotechnology
- Quantum Metrology
- Photonics
- Functional Materials
- Mathematical Modelling

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Priority Areas of Research

- **Nanotechnology**
  - Nanoscale probes
  - Single electron devices
  - Nanomaterials
  - Virtual foundry
- **Biotechnology**
  - Physical structure of biological molecules and surfaces
  - Correlation of identity and structure of proteins to their functions
  - Fluorescence standards
  - Single molecule characterisation
- **Mathematical Modelling**
  - Molecular modelling of fluids
  - Modelling for nanotechnologies

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Priority Areas of Research

- **Quantum Metrology**
  - Optical frequency standards
  - New current standard
  - Single particle detection and identification
  - Fundamental constants determination
- **Functional Materials**
  - Piezo electric materials
  - Magnetic materials
- **Photonics** (under consideration)
  - Photonic materials
  - Display technologies

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‘If, then, we wish to obtain standards of length, time mass which shall be absolutely permanent, we must seek them not in the dimensions, or the motion, or the mass of our planet, but in the wavelength, the period of vibration, and the absolute mass of these imperishable and unalterable and perfectly similar molecules’

Maxwell 1870

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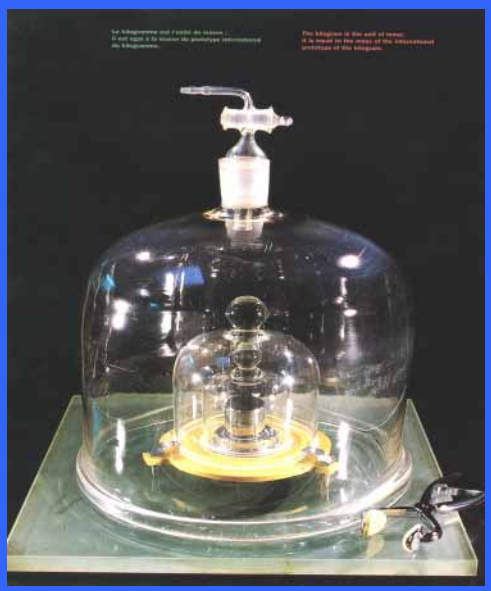
The Kilogram



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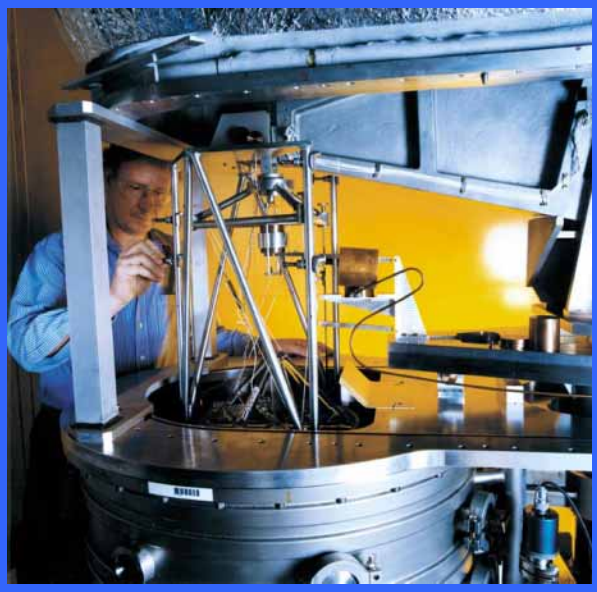

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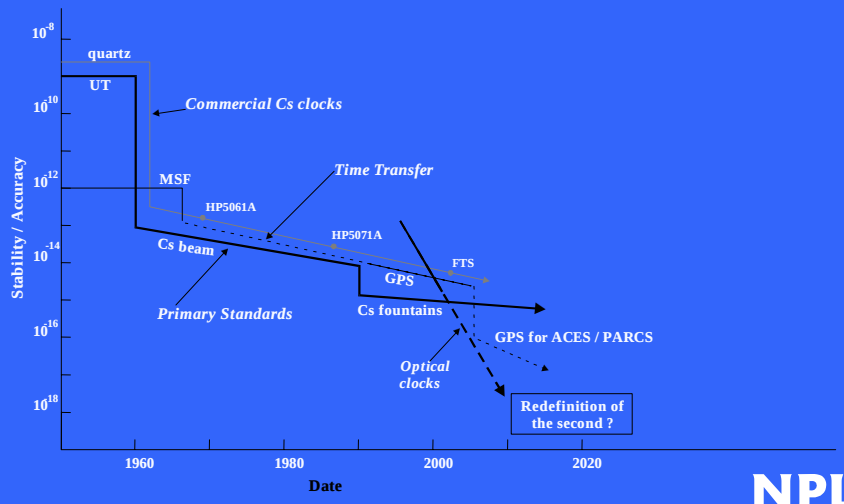
Evolution of primary frequency standards, timescales and commercial clock performance



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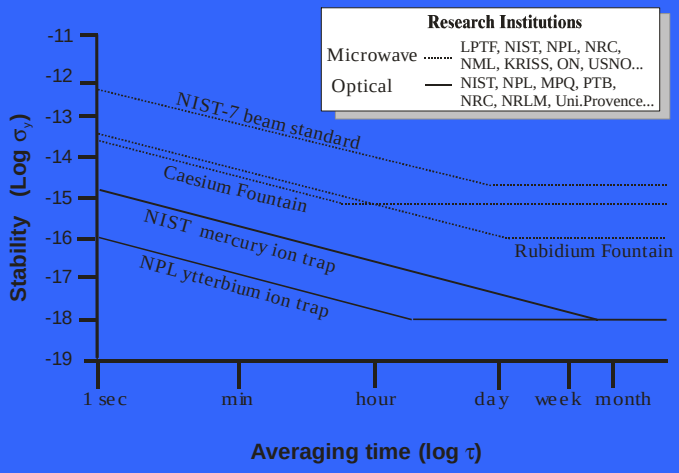
Major opportunities for improved frequency standards



Limiting stabilities and reproducibilities for various microwave and optical frequency standards

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NPL Optical Clock Apparatus

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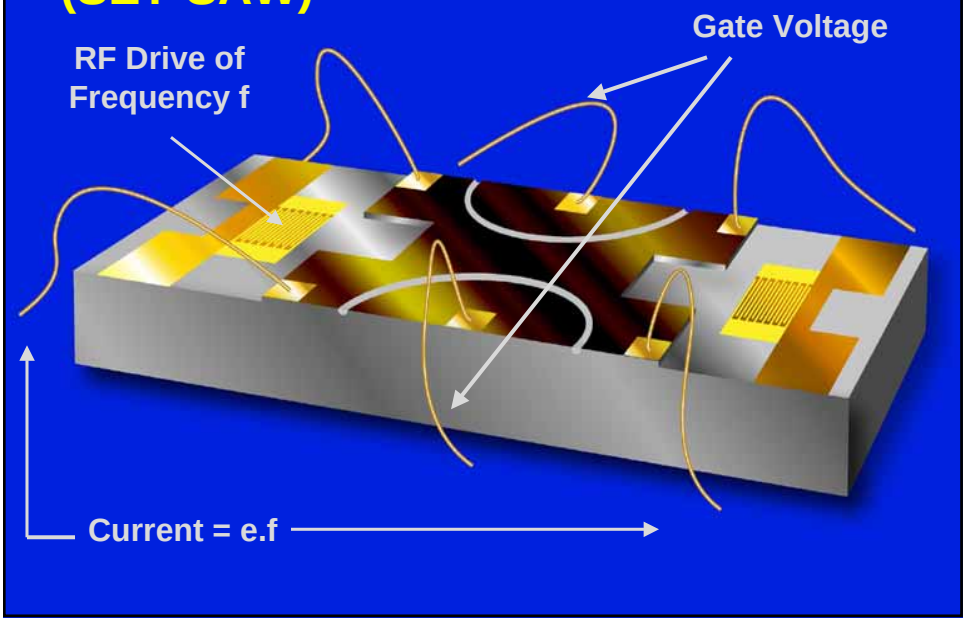
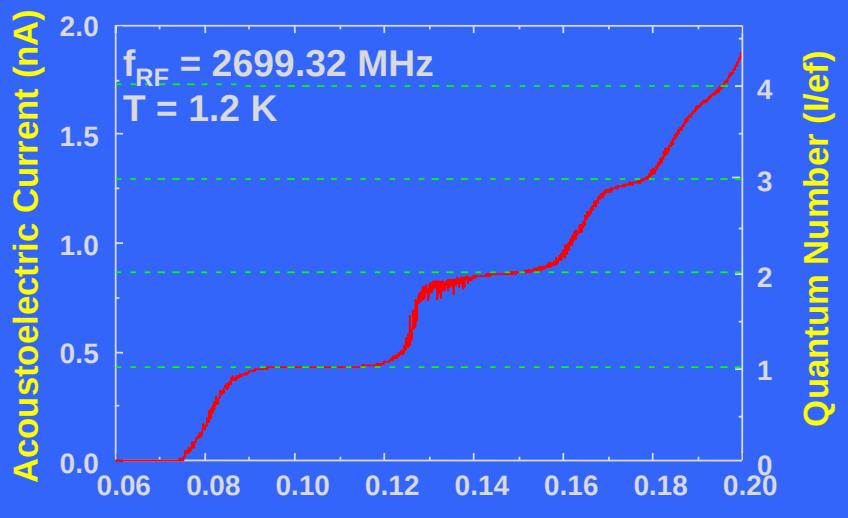
Acoustoelectric Current Device (SET-SAW)



Current Versus Channel Width



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Heading in a new direction

1. Action plan
2. Internal communication
3. Invest in strategic research
4. Build capability
5. Establish strategic partnerships

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Technology & Measurement Challenges

Technology	Key Areas	Key Beneficiaries & Applications	Some Key Measurement Challenges
Nano-technologies	Nanoprobes Nanoelectronics Nanobiology Nanofluidics	Medical Electronics materials	3D sizing; Molecular Imaging; Materials Properties; Spectroscopy Atomic Distribution; Temperature Fluctuations

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Technology & Measurement Challenges (2)

Technology	Key Areas	Key Beneficiaries & Applications	Some Key Measurement Challenges
Biotechnology	Genomics Proteomics Genetic Modification Diagnostics	Agriculture Medical Pharmaceuticals Security	Molecular Sampling; Chemical Location Specificity; Dynamic Measurements (time/spatial); Measurements in Nanometre scale Structures; Measurement in Living Organisms; Measurements in Solvents; Measurements in Water; Simple Spin Detection; Terehertz Imaging

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Technology & Measurement Challenges (3)

Technology	Key Areas	Key Beneficiaries & Applications	Some Key Measurement Challenges
Photonics	Opto electronics Lasers Display Technologies	Communications Media Medical Transport Pharmaceuticals	Chemical/Surface Analysis; Atomic Level and 3D Characterisation; Single Photon Generation and Detection; Quantum State Measurements; Quantum State Coherence Properties; Fibre Optic Bandwidth Traceability; Femto and Atto Second Optics; High Speed Electrical Characterisation

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Examples of future measurement activities

Measurements/Techniques	Laboratory Environmental Requirement
Fast Scanning Probe Microscopy (AFM, STM, SNOM), optical tweezers	± 0.01ºC, 45 ± 5% humidity control, <1 picometer at samples displacement, low stray electromagnetic fields, RF isolation, class 10,000 clean room, contamination control, acoustic decoupling
Single and low photon generation and detection, quantum state measurement, quantum state coherence properties, non-invasive measurement of quantum states	± 0.1ºC, 45 ± 5% humidity control, <1 micrometre/s displacement, class 100 – 10,000 clean rooms, low stray fields, <1 nanotesla noise level, possible contamination control, non-magnetisable environment, acoustic decoupling
Optical clocks, fountain clocks, optical radiometry, femtosecond comb metrology	± 0.01ºC, ± 0.02ºC, 45 ± 5% humidity control, <1 micrometre/s displacement, low stray fields, <1 nanotesla noise level, non-magnetisable environment, class 100 – 10,000 clean rooms, possible contamination control, acoustic decoupling

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