# TECHNOLOGY SYNERGIES ACROSS AGILENT

Agilent Technologies

# CREATING COMPELLING CUSTOMER VALUE

Synergy is defined as two or more components working together to produce a result not obtainable by any of the components independently. This chart highlights important technology synergies in Agilent that have unleashed the imaginations of our customers and helped advance major technology and market waves over the past seven decades.

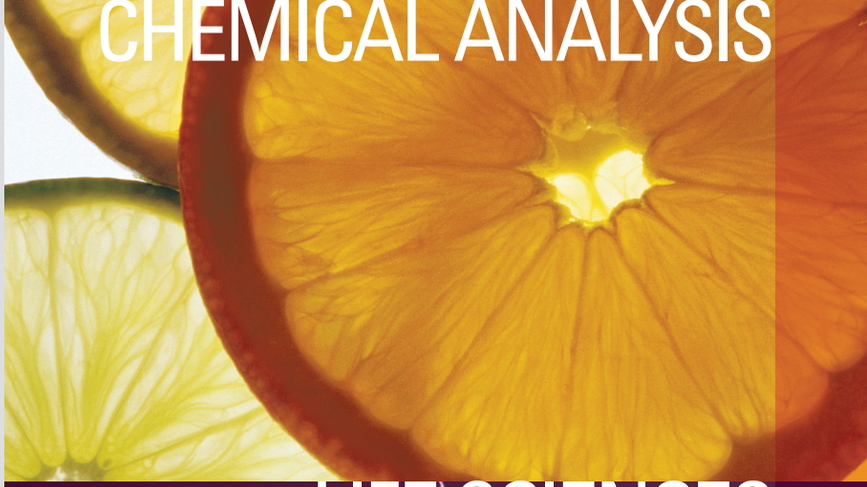
Throughout our history, Agilent has invested heavily in research and development, firmly committed to technology leadership. Our depth and breadth of disciplines and technologies enable unique and often breakthrough advancements that transcend traditional boundaries.

Particularly powerful innovations result when we combine very different technologies to form something entirely new. Some synergies on this chart involve new inventions, and some meld disparate existing technologies. All have contributed results that are truly revolutionary.

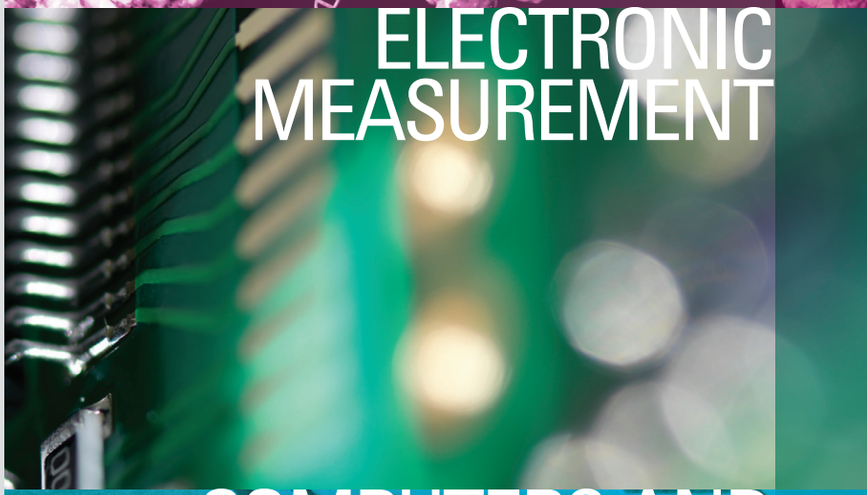
A significant number of these synergies have their origins in Agilent Research Laboratories, our advanced central research labs. At the crossroads of the organization, the labs identify and enable technology synergies across Agilent to advance measurement and achieve sustainable competitive differentiation. Teams from the labs and businesses collaborate at all levels to understand continually evolving customer needs, market conditions and technology goals.

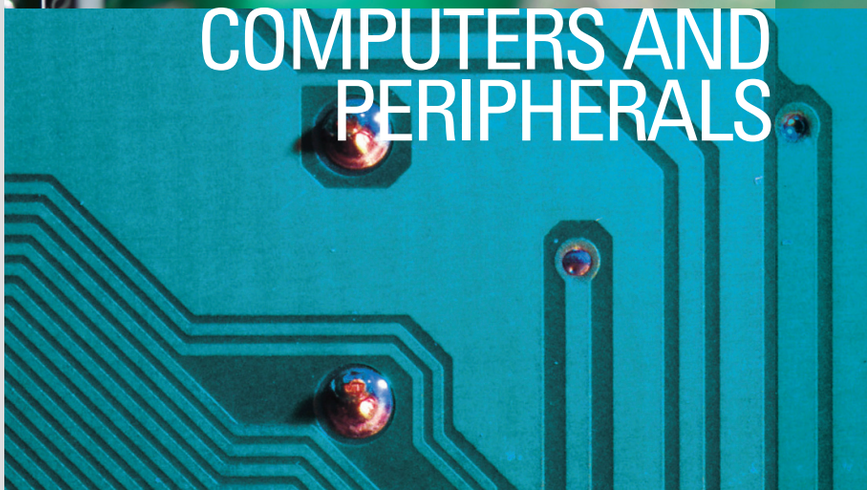
Empowered business teams lead research, product development, manufacturing, quality, marketing, sales, service and support. Exceptional teamwork enables seamless global collaboration. Agilent instruments are consistently among the highest in quality and reliability in the industry, with outstanding customer loyalty. Our corporate functions partner worldwide to drive to a world-class and cost-effective infrastructure.

Together we chart future directions, successfully innovate technologies and commercialize leading-edge solutions that create real value for our customers.



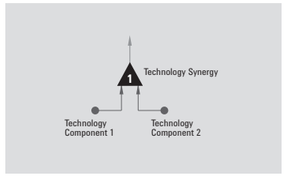




# AGILENT: SEVEN DECADES OF INNOVATING ACROSS BOUNDARIES

READING THE DIAGRAM




ELECTRONIC MEASUREMENT

LIFE SCIENCES

COMPUTERS AND PERIPHERALS

CHEMICAL ANALYSIS

(HP AFTER 2000)

2010
2000
1990
1980
1970
1960

**1939**

Optical Modulation Analyzer 25
Millimeter Wave Imaging 19
Semiconductor Optical Sources and Detectors
RF and Microwave Electronics and Signal Processing including Pulse Counting
30 GHz Oscilloscope 21
Atomic Force Microscopy
Scanning Microwave Microscope 20
DNA Microarrays
Capillary Electrophoresis
Biosciences
Next Generation Nuclear Magnetic Resonance 26
Bioinformatics
Time-of-Flight Mass Spectrometer Signal Enhancement 22
Accurate-Mass Time-of-Flight Mass Spectrometer 15
Chip Liquid Chromatography 12
Ultra High Pressure Liquid Chromatography 23
Liquid Chromatography/Mass Spectrometry 6
Liquid Chromatography
Fused Silica Capillaries for Gas Chromatography
Mass Spectrometry
Deans Switch for Capillary Gas Chromatography 17
Gas Chromatography/Mass Spectrometry 4
Gas Chromatography 3
Surface Chemistry
UV–Visible Spectroscopy 5
Varian's Nuclear Magnetic Resonance Technology
Silica Optical Fibers
Quantum Electronics 1
Heterodyne Distance Measuring Interferometry
Microwave Substrate Technology
High Performance Data Converters for Oscilloscopes and Other Instruments 10
Signal Processing for Communications
RF Spectrum and Network Analyzers 7
Photonics Technology and Test Equipment 8
Telecommunications Test Technology 11
Tunable Lasers
Photonics Analyzers
Network Surveillance 24
Radio Frequency Surveillance
Time Synchronization and IEEE 1588 18
Network Monitoring 9
Microwave Spectrum and Network Analyzers
Microwave Integrated Circuits
Ultra High Precision Mechanical Technology
Silicon Integrated Circuit Design and Fabrication
Inkjet Printing
Desktop Calculators 2
Pocket Calculators
Computer Science, Mathematics of Computation and Image Processing
Optical Mouse 13
Spatial Correlation

# A CLOSER LOOK AT TECHNOLOGY SYNERGIES

### 1. HETERODYNE DISTANCE MEASURING INTERFEROMETRY

This dates from 1971, and since then has been crucial in the lithography step that is key to the manufacture of integrated circuits. Over its long life this technology has been continuously refined, and today is capable of sub-1 nm measurement at extremely high data rates. It came about as the synergy of two long-standing HP/Agilent capabilities: quantum electronics and high-speed pulse counting. The former also led to the frequency standards that make Global Positioning Systems (GPS) possible.

### 2. POCKET CALCULATORS

In 1972 we introduced the world's first pocket calculator, the HP35, with our proprietary chips, semiconductor optical source technology for the red display light emitting diodes, high-quality contacts for key pads and special algorithms for calculations. Mathematical users appreciate the Reverse Polish Notation (RPN) capability that enables them to enter complicated arithmetic expressions. Since Agilent became a company in 2000, HP has continued this business.

### 3. GAS CHROMATOGRAPHY/ MASS SPECTROMETRY (GC/MS)

Based on our hyperbolic quadrupole technology, a technique to optimize an electric field, we were well-positioned in the 1970s to combine GC technology and quadrupole MS technology into the first benchtop GC/MS system. This system contributed significantly to growing customer needs in environmental measurement. We became and remain the GC/MS market leader by advancing the platform with innovations such as quartz quadrupoles, inert sources and column connection technology.

### 4. FUSED SILICA CAPILLARIES FOR GAS CHROMATOGRAPHY

When we entered chemical analysis in 1965 with the acquisition of F&M Scientific Corporation, packed columns were used pervasively. Because these columns were made of rigid, fragile and chemically active glass tubing, system configuration and maintenance were challenging. In the 1970s we manufactured fused silica optical fiber in our electronics business for optical communication, and we adapted this process to make thin fused silica tubing for GC columns. The new silica columns were flexible and much more chemically robust than the glass columns. This revolutionary innovation now leads the field and contributes to the success of our market-leading gas chromatography instruments.

### 5. UV-VISIBLE SPECTROSCOPY

In 1979 we introduced the world's first commercial diode array spectrometer to analyze optical properties of materials and chemicals. This breakthrough combined integrated circuit technology and the spectrophotometer—which leveraged emerging technologies of holographic diffraction gratings, aspheric replicated optics and microprocessor control—to develop the first diode array detector to measure analytically important wavelengths. Agilent spectrometers continue to help identify substances by accurately measuring their emitted or absorbed spectrum.

### 6. LIQUID CHROMATOGRAPHY/ MASS SPECTROMETRY (LC/MS)

In the 1990s we leveraged our leadership in benchtop GC/MS systems by integrating our hyperbolic quadrupole technology with an electrospray ionization source to launch the bench-top liquid chromatography mass spectrometer (LC/MS). Through continuous innovation such as the Jet Stream thermal focusing technology, Agilent has evolved this platform into triple quadrupole LC/MS systems, which provide very high performance separation and identification of complex mixtures.

### 7. MICROWAVE SPECTRUM AND NETWORK ANALYZERS

In the 1960s we introduced the first spectrum and network analyzers for accurate measurement and analysis of radar and telecommunications signals and components. A key synergy was the development of YIG (Yttrium Iron Garnet) solid-state oscillator technology that provided a precision linear multi-octave microwave source. The YIG oscillators, combined with our GaAs microwave integrated circuits, extended the range of these instruments to more than 100 GHz by the mid-1980s. The electronics industry uses these analyzers for broadband characterization of RF and microwave signals and components for cell phones, computer backplanes and cable test.

### 8. PHOTONICS ANALYZERS

In the late 1980s we introduced photonics analyzers for measurement in fiber optics communications including laser transmitters and receivers, optical fiber and optical components. We combined our tunable lasers with microwave spectrum and network analyzer technologies to create a new class of photonics instruments that measure noise on lasers, electro-optical properties of lasers and signal distortion-inducing effects in photonics components. Our industry-first optical spectrum analyzer employed a receiver similar to radios but worked at frequencies a factor of 200,000 higher, enabling a 1,000-fold improvement in optical resolution compared to earlier instruments. Researchers can visualize photonic signals and measure laser spectra with much greater precision than previously was possible.

### 9. NETWORK MONITORING

Our expertise in telecommunications test technology dates back to 1965. In 1992, augmented by our capabilities in time synchronization and computational mathematics, we developed a powerful new monitoring technology for SS7 telecommunications networks, and by 2005 this had become massively parallel and automated.

### 10. CAPILLARY ELECTROPHORESIS (CE)

In the early 1990s we realized that the technology to fabricate fused silica GC capillary columns also could make tubing for capillary electrophoresis, a technique to separate biomolecules. UV spectroscopy was the detection method across a "bubble cell" blown in the capillary. We later miniaturized electrophoresis technology to launch the Agilent Bioanalyzer platform, in partnership with Caliper Life Sciences. The Bioanalyzer was the first commercial instrument to use microfluidics technology to analyze biological samples and is the gold standard today for nucleic acid quality analysis.

### 11. TUNABLE LASERS

Much like the first HP audio oscillator and YIG-based microwave oscillator, tunable lasers provided the optical source to support a wide variety of measurements, in this case for optical communications. Applying the optical source technology to the new field led to the first reliable tunable laser in the late 1980s. These precision laser sources form the foundation of a variety of measurement instrumentation and will continue to provide the laser light needed for new generations of photonics equipment.

### 12. CHIP-LIQUID CHROMATOGRAPHY

Laser ablation is a technique HP used to manufacture inkjet printhead nozzles. In the late 1990s we explored laser ablation to fabricate polymer-based microfluidics structures for bioanalytical measurement. The first chip-LC products introduced in 2005 integrate on-chip high-pressure liquid chromatography separation and direct electrospray injection into a mass spectrometer. Sensitivity, sample size requirements and ease of use are improved significantly compared to traditional liquid chromatography.

# CREATING BREAKTHROUGH INNOVATIONS

### 13. OPTICAL MOUSE

In the 1980s HP realized that the fibrous structure of paper enables navigation across the surface. We made this practical with capabilities in integrated circuit design and light emitting diodes. In 1996 the blockbuster optical mouse soon displaced track-ball mice from the computer navigation market. In 2004 Agilent improved surface tracking by 20X with infrared laser technology we developed for fiber optic communications. This contribution allowed the mouse to operate on a wide variety of surfaces from carpet to photo paper. Avago Technologies (divested in 2006) continues to produce computer mice based on this technology.

### 14. DNA MICROARRAYS

Agilent's expertise in DNA biochemistry, image analysis and inkjet printing (from HP) was key to development of DNA microarrays. Agilent launched the first products in 2000, incorporating expertise from Rosetta Inpharmatics. Agilent continues to advance this technology independently, creating genomics applications that benefit from the flexibility and high quality of our arrays. Our core competencies in inkjet printing and nucleic acid fabrication enabled Agilent to launch new businesses in RNA synthesis for therapeutic manufacturing and oligonucleotide library solutions, such as the SureSelect Target Enrichment System for DNA sequencing. Acquisitions of Stratagene and Velocity 11 provide bioreagents and automation that further enhance these businesses.

### 15. ACCURATE-MASS TIME-OF-FLIGHT MASS SPECTROMETER

We entered mass spectrometry in 1970 with quadrupole technology for mass selection. Today our Accurate-Mass time-of-flight (TOF) and Accurate-Mass quadrupole time-of-flight (Q-TOF) mass spectrometry systems are among the highest performance commercially available. Agilent leverages high-speed oscilloscope technology to TOF capability, because digitization in both areas involves high-speed data conversion and digital signal processing. At low mass, ions arrive so rapidly at the detector that high-speed digitization is required to capture the arrival rates. Agilent is the only mass spectrometry company with proprietary data conversion technology and is not limited to data converters available commercially.

### 16. BIOINFORMATICS

The connection between the design of highly complex computer and data processing chips (developed since the late 1960s) and the life sciences (1990s) is not obvious. The common thread is the flow of information through networks. In digital circuits, networks comprise logic gates, and the information consists of digital "bits." In life sciences, networks comprise cellular interactions between genes, transcription factors, proteins, metabolites and other biomolecules.

### 17. DEANS SWITCH FOR CAPILLARY GAS CHROMATOGRAPHY

Deans switch technology enhances capillary column gas chromatography by permitting switching of gases between two or more columns. Miniaturization of these switches significantly reduces the "dead volume," the unwanted residual volume of gas residing in the switch itself; here we leverage our high precision metal fabrication capability developed for producing high frequency microwave network components and standards for electronic measurement.

### 18. RADIO FREQUENCY SURVEILLANCE

Agilent's RF surveillance technology identifies and physically locates unknown emitters within a wireless network. This synergy stems from our expertise in RF spectrum analysis and time synchronization within networks, which led to the IEEE 1588 standard. The 1588 technique allows large computer, telephone and video networks to be synchronized to within 20 nanoseconds.

### 19. MILLIMETER WAVE IMAGING

In the early 2000s state-of-the-art millimeter wave imaging systems used mechanically scanned linear transceiver arrays and took more than a minute to produce an image. Agilent harnessed its millimeter wave and lightwave technologies for a new approach; combining a single transceiver and an electronically controlled phased array antenna eliminates all moving parts and produces live real-time video. The antenna's computer generated millimeter wave holograms leverage previous research in diffractive optical elements for optical communications. Agilent licensed this technology to address the need for fast, accurate screening of people in airports.

### 20. SCANNING MICROWAVE MICROSCOPE

Network analyzers, image processing and atomic force microscopes (2005 acquisition of Molecular Imaging) are key Agilent technologies. In 2008 Agilent created an entirely new measurement platform—scanning microwave microscopy—by combining these three core capabilities from our electronic and bioanalytical businesses. The resulting platform provides significant new surface characterization capability for engineers and life scientists.

### 21. 30 GHz OSCILLOSCOPE

For several decades, Agilent has developed some of the world's highest performance integrated circuit technologies using gallium arsenide, indium phosphide and other compound semiconductor materials. These exotic materials enable performance unobtainable by conventional silicon IC technology, often leading to instrument specifications that competitors cannot match. Agilent's 30 GHz oscilloscopes include the synergy of our wide bandwidth proprietary compound semiconductor chips, our high performance ceramic microcircuit technology and Agilent-designed 20 billion sample per second CMOS analog-to-digital converters.

### 22. TIME-OF-FLIGHT MASS SPECTROMETER SIGNAL ENHANCEMENT

The time-of-flight mass spectrometer provides chemical information in a digital form. We are applying advanced digital signal processing techniques, originally developed for communications, to TOF-MS to significantly increase system performance for chemical and bioanalysis.

### 23. ULTRA HIGH PRESSURE LIQUID CHROMATOGRAPHY (UHPLC)

Our microfluidic heat exchanger and mixer enable the Cougar-B binary pump, which is the heart of the Agilent 1290 Infinity UHPLC. Thanks to leading edge metal fabrication capabilities developed for microwave measurement products, the UHPLC system offers 1200 bar operating and 2000 bar burst pressure ratings, performance unmatched in the industry.

### 24. NETWORK SURVEILLANCE

In 2007 engineers realized that technologies to assure telecom network performance also could monitor network security. Based on this passive telecom network management expertise, Agilent launched a new business in network surveillance that couples our telecom solutions with our strengths in RF surveillance.

### 25. OPTICAL MODULATION ANALYZER

In 2009 we introduced the optical modulation analyzer (OMA) to measure the new types of signals (utilizing phase and polarization properties of light) that increase efficiency of fiber-optic pipes that transport Internet traffic. The OMA combines our tunable lasers, advanced photonics test algorithms, wide bandwidth oscilloscopes and vector signal analysis software used in microwave spectrum analyzers for wireless communications. These analyzers enable communications researchers to tune to an optical wavelength channel, quickly assess the quality of the complex 100G signals on that channel and measure degradations due to the fiber optic link.

### 26. NEXT GENERATION NUCLEAR MAGNETIC RESONANCE (NMR)

With the acquisition of Varian in 2010, Agilent added NMR to our portfolio. Varian has been developing its core competency in NMR since 1946, two years before its incorporation. We are continuing to advance NMR beyond its state-of-the-art today by integrating our world-class capabilities in RF electronics and signal processing that date back to HP's founding in 1939.

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