Cleanrooms
IIoT and Remote O&M

Overview

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Suppliers

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Overview

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Cleanroom IIoT and Remote O&M Market will exceed $11 billion in 2026

Operators of cleanrooms in the pharmaceutical, semiconductor and other industries requiring ultra clean environments will invest $5.1 billion in new rooms and other capital equipment plus an additional $7.1 billion in consumables and outside services this year. N6F World Cleanroom Markets Of this total $1.2 billion will be spent for IIoT and Remote O&M. The IIoT segment will grow rapidly over the next decade and reach $11 billion by 2026. N031 Industrial IOT and Remote O&M

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Cleanroom Revenues

Cleanroom Revenues - $ millions					
Continent	2017 Capital	C&S	Total	IIoT 2017	IIoT 2026
Total	5,100	7,140	12,240	857	7,711
Africa	50	70	120	8	77
America	1,100	1,540	2,640	185	1,663
Asia	3,300	4,620	7,920	554	4,990
Europe	650	910	1,560	109	983

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Cleanroom Revenues, cont.

- Asia will dominate the market due to its continued expansion of electronics manufacturing and its leading role in generic drugs.
- The IIoT & Remote O&M applied to the manufacturing processes will be much larger but cleanrooms will also be an important segment. The challenge is to integrate the offerings of the cleanroom suppliers with the digital process management of the facilities. To put this in perspective let's explore some cleanroom supplier examples and then determine how that fits into a broader program offered by a company which is involved with both.

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Berendsen has an IIoT Opportunity with its own Laundries and Customer Facilities

Berendsen has eleven cleanroom laundries in Europe which supply consumables as well as laundered garments. It can remotely monitor and control the air quality in each of its own cleanrooms as well as the air in customer's plants. It can also manage the inventory of garments, clogs, goggles, mats and other accessories. It can include logistics solutions and even control the customer's internal logistics processes.

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Vaisala Continuous Monitors Keep Pharma Cleanrooms Audit Ready

Vaisala's instruments and solutions reduce the risk of out-of-specification conditions and help keep pharmaceutical and biotechnical cleanrooms audit-ready and compliant with a continuous monitoring system which offers:

- Low cost of ownership due to easy connectivity to an existing network, remote access, and scalability up to thousands of monitored locations
- Customizable reporting for easy cleanroom certification and classifications
- Gap-free and protected data records required in GxP environments
- Audible and visual alerts, as well as alarming via sms, e-mail, pager and many more
- Custom reports that are automatically generated and delivered by email on demand
- Measurement of humidity, temperature, differential pressure, flow, particulate and more
- Both wired and wireless sensor option available

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Terra has Wireless Control System to minimize Cleanroom Fan Energy Consumption

- Terra's latest-generation Wireless Cleanroom Control System offers convenient power management to optimize efficiency and cut operating costs. The system can accomplish the following tasks.
- Turn off lights and air conditioning and put fan filter units in energy-saving mode at the press of a control switch or remotely via iPhone app
- Set up automatic scheduling to control cleanroom operation (FFUs, lights, temperature) based on operating hours
- A/C and other energy cost savings on weekends and off-hours provide fast ROI (typically within a year)
- Remote Internet monitoring and control—check operation and make changes from home

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Lighthouse Software Provides Tracking of Air Cleanliness and Conditions

Lighthouse LMS Express Software monitors multiple environmental parameters. All this data can be integrated into LMS Express Software and can be centrally located.

The environmental parameters which can be monitored include the following, Particle Counts, Temp/RH, Differential Pressure, Air Velocity, Door Status, CO_2 Levels, Viable Particles, O_2 Levels.

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Mahindra Remotely Monitors Indian Cleanrooms

- A $17.8-billion multinational group based in Mumbai, India, Mahindra is involved in a number of industries. One is cleanrooms. The IIoT solution is designed to monitor and control cleanrooms in pharmaceutical manufacturing companies. It leverages expertise in Big Data and the Cloud. Cleanroom monitoring ensures minimum human intervention thereby preventing contamination in aseptic condition. The solution increases the compliance to standard procedures and monitors equipment remotely from a central location. The system achieves the following:
  - Helps avoid contamination through minimal human intervention
  - Compliance to equipment maintenance schedule and log management
  - Prevent human errors through automation and capture of machine data
  - Wireless communication to comply with cleanroom standards
  - 21 CFR Part 11 and other global regulatory standards compliance
  - Sensors enabled continuous monitoring and control of equipment and process
  - Remote monitoring and control from anywhere any time
  - Multi-location monitoring and control
  - Alerts for deviations and corrections before they become a major problem

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ENVIRCO Controls Air Flow in Cleanroom Filtration System

- ENVIRCO® offers a complete family of control solutions providing machine intelligence to monitor and control cleanroom environments of all sizes — from small to very large. Both fan filter units and ballroom filter systems can be monitored. Other features such as door interlocking and event logging and reporting can be incorporated.

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ABB is involved from Products through Complete IIoT Solutions

- ABB Robotics has introduced an ISO 5 (Class 100) Cleanroom version of the IRB 120, its smallest ever multipurpose 6-axis robot. The component materials of the IRB 120 prone to particle generation have been modified to eliminate the potential for contamination of the manufacturing area and the parts being processed.
- ABB is shaping and focusing its divisional structure into four market-leading divisions: Electrification Products, Robotics and Motion, Industrial Automation and Power Grids. The divisions are empowered as entrepreneurial units within ABB, reflected in an enhancement of its performance and compensation model focusing on individual accountability and responsibility. They benefit from sales collaboration orchestrated by regions and countries as well as from the group-wide digital offering; ABB's leading G&A structure and costs; common supply chain management; and corporate research centers.
- This sales collaboration is a welcome initiative. It has been the McIlvaine experience that most large multi divisional companies do not take advantage of the divisional synergies. McIlvaine has explored the Industrial Internet of Wisdom (IIoW) as a way to empower IIoT. The interconnection of individuals within the supplier companies is an important aspect of IIoW.
- The Industrial Automation division succeeds the former Process Automation division. ABB will drive digitalization across industry sectors, building on its #1 position in process control through software and services. ABB has domain expertise that allows it to master the control room in a wide range of industries such as pharmaceuticals, mining, shipping and oil and gas. By focusing on growing segments and bringing together maintenance, operation and control, ABB will drive penetration of strongholds and create differentiation for customers.

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ABB’s Comprehensive IIoT Solutions

- ABB has comprehensive IIoT solutions for industries utilizing cleanrooms. Its manufacturing execution systems (MES) play an essential role in achieving sustainable competitive advantages in the life science industry today. They enable higher plant efficiency and productivity as well as greater flexibility and agility throughout the production processes.
- ABB collaborates with a leading pharmaceutical MES supplier, Werum IT Solutions GmbH based in Lüneburg, Germany, on control system solutions for life science industries.
- Werum's PAS-X out-of-the-box software product is operating in approximately 800 installations of the world’s pharmaceutical and biotech companies. Manufacturing IT products from Werum IT Solutions help pharmaceutical manufacturers increase efficiency, improve productivity, and meet regulatory requirements.

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ABB's Comprehensive IIoT Solutions, cont.

- The collaboration on the joint solution complements ABB's control systems offering with the latest MES technology, which is seen as a key component for efficient production workflows in the life science industry. By bringing together both offerings, ABB and Werum IT Solutions will be able to deliver full scope engineering and validation solutions according to the GAMP5 guideline, and comply with regulations, such as FDA (21 CFR part 11). MES capabilities include:
  - Production order management
  - Quality management
  - Weigh & dispense.
  - Warehouse management:
  - Standard operating procedures (SOPs) – bringing consistency to manual operations by guiding the operator through each step with the required production and safety instructions and checks.
  - Paperless manufacturing – electronic batch record.

Just as ABB incorporates Werum in its cloud based solutions it can also collaborate with Envirco, Mahindra, Lighthouse, Terra, Vaisala and Berendsen to provide the full range of remote support systems.

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IIoT will allow Smaller Chip Companies to Compete

- Adam Lesser predicts that standards will materialize that allow more than just highly capitalized semiconductor manufacturers to implement IoT and advanced machine control techniques in their processes. Why? The payoffs in terms operational efficiency are just too big. And as analytics improve, and perhaps even come down in cost, the case for a highly networked and automated industrial push will grow.
- “We should look to the semiconductor industry as an example of what’s possible. The difference, of course, is that other industries often don’t have the degree of capital available to the semiconductor industry. But as standards improve and industrial IoT matures, the returns for less sophisticated industrial processes should also creep up.”

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Semiconductor Manufacturing will lead the Way to IIoT for Other Industries

- In the case of semiconductor production, manufacturing involves very precise processes in order to create layers of transistors with specific operating characteristics. Chemical and photolithographic steps are used to harden an exact representation onto a silicon wafer. Wafers are then cut into individual chips and electrical contact points are added.
- As semiconductor fabrication processes reach 22 and 14 nm, manufacturers are able to pack more chips on a single wafer. Cutting and dicing of the wafer requires precision measuring on the scale of a thousandth of a millimeter. Blades and lasers are used to accomplish this etching and they function in multiple axes of motion and must integrate feedback about positioning at high resolution.
- Additionally, delivery of control data between sensors and controllers has to have a latency of less than 100 microseconds. Add to this complexity the reality that cameras and video are increasingly being integrated into manufacturing and they have high bandwidth requirements. Bandwidth limitations at any step in the system create problems and if maintenance and diagnosis is to be handled remotely, connectivity into the lowest layer of a machine must be secure and real-time.
- The semiconductor industry will lead the way with cleanroom IIoT as part of programs for entire manufacturing processes. Other industries will be able to benefit from these pioneering efforts.

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Semiconductor Manufacturing will integrate Cleanroom IIoT as Part of a Much Larger Effort

- In the semiconductor industry, much attention has been on the transitions to new transistors (finFETs), lithography tools (EUV), and wafer sizes (450). But the Internet of Things is on the chipmakers agenda as well. Connectivity is providing data from tools so that problems can be solved more easily. Predictive maintenance, intelligent scheduling, advanced process controls - all are making progress. Another equally important challenge exists: how to deal with Big Data - the analysis of huge streams of data coming from sensor-laden and increasingly connected fabs.

  “Deploying intelligent systems effectively is management’s top challenge,” said Tom Sonderman, a consultant who was a pioneer in advanced process control while at AMD and GLOBALFOUNDRIES. “Equipment companies have had their silos: hardware and software, and between the different product groups working on deposition, etch, and so on. Managers such as (Applied CEO) Gary Dickerson get it: they have to break down the walls.”

  Sonderman lists “management mindset” among the attributes needed for a winning Big Data solution. Technology must be joined with a service-minded organization able to turn data into usable information. Finally, companies must emphasize fast response times and have an awareness of total cost of ownership (TCO).

  A leading-edge fab might contain >1,000 tools, with several dozen key sensors on each tool, and each wafer may see as many as ~1,400 process steps. Huge streams of information are coming from fab tools, wafers, GDS (design) files, and facilities.

  “All of this information is like a sunken treasure; you have to figure out how to get it into the boat,” Sonderman said.

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AGS moving to Data Driven Analysis with IIoT to help make Maintenance Decisions

- The data coming from fabs is expected to triple, from 50 terabytes (TB) at the 45nm node to 140 TB at 20nm design rules, according to John Scoville, senior director of application engineering in the Applied Global Services (AGS) group. A typical 300mm tool might have 500 system variable identifiers (SVIDs) running at 5 Hz, while a 200mm tool has about 160 SVIDs operating at 1 Hz. Making sense of all that data is part of an advanced technology-enabled services push at AGS, where Applied engineers work in close partnerships with the engineering teams at semiconductor manufacturers. These productivity-enhancement projects focus on excursion control, predictive maintenance, scrap reduction, chamber matching, and reduction of particles/defects, among others.

  Alex Schwarm, senior product manager in the AGS group, said technology-enabled services go beyond the maintenance-driven relationships Applied has established with scores of chipmakers. Most of the large chip makers, Schwarm said, are already collaborating with Applied on data-driven analysis projects, drawing upon Applied's E3 performance-tracking and data mining software, as well as libraries and models. "We have developed a method of working with the customer to help them determine how and what to analyze. It is not a closed box, it is more interactive and integrated than a typical maintenance relationship. You are now an extension of the customer's team. Rather than silo things, which you can easily do with a maintenance service relationship, for these device- and film-oriented problems we need to be more integrated into the customer's team."

  Most semiconductor manufacturers have worked with Applied on process challenges. "They want to know the long-term strategy," Schwarm said. "There is a change in what customers expect from Applied, from how best to replace parts or fix electromechanical issues, to a different type of value, based on a specialized skill set and data analysis and management capabilities we bring to the table."

  For every dollar invested in the collaboration, the customer looks for yields and productivity to improve measurably.

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Suppliers

Danaher - Met One

Dickson

SenseGrow

Thermo-Fisher

TSI

VWR

Danaher - Met One Facility Monitoring Systems integrated with Enterprise Information Systems

MET ONE facility monitoring systems are scalable on-line particle monitoring solutions based on open architecture communications that integrate easily with preferred systems. The full suite of remote and portable air particle counters feature full ISO 21501 compliance and 21 CFR Part 11 compliant data management software.

- MET ONE will manage the design and install of your particle counting facility monitoring system
  MET ONE offers project management, system definition and design, software customization, validation, and installation services.
- MET ONE facility monitoring systems will integrate into your existing legacy systems
  Integrate its instruments with an existing Enterprise Information Systems, LIMS, or Building Management System.
- MET ONE gives you on-site service
  Large industry global network of local service offices with fully compliant on-site service for instruments, including full ISO 21501-4 calibrations. the service agreement programs provide proactive pre-scheduled on-site calibration and maintenance services, including discounts for any repairs.
- MET ONE facility monitoring solutions eliminate data silos within multiple systems
  Eliminate validation, maintenance, and upgrades for multiple monitoring systems Eliminate multiple reports by including non-viable particle data with all other production data.
- MET ONE compliance services
  SOP development assistance for manual monitoring Full validation documentation packages for automated systems URS planning Validation documentation packages (Installation Qualification/Operation Qualification) Validation testing process and final sign-off assistance.
- MET ONE offers a full suite of environmental sensors and system accessories
  Relative humidity and temperature sensors Air velocity sensors Differential pressure sensors IO modules connect to existing sensors, door switches, tool interrupts, etc. Ethernet switches, touch-screen NEMA computers etc. Distributed vacuum systems Distributed DC power systems Multi-function alarm modules

Met One is part of the Beckman Coulter group which in turn is owned by Danaher. The IIoT commitment of Danaher is reflected in the next two slides.

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Danaher Optimistic About IIoT Potential

- Danaher is bullish on IIoT. It sees multiple opportunities in the recurring revenue sector. Examples of recurring revenue include consumables and services in diagnostics and life sciences, and across Pall Corp.'s operations.

- The opportunity facing Danaher comes from embedding more software in its equipment, thereby spurring increased consumables sales and keeping customers engaged with Danaher's services. Moreover, analyzing data from customer usage of equipment can create valuable opportunities for the company to modify its customer offerings.

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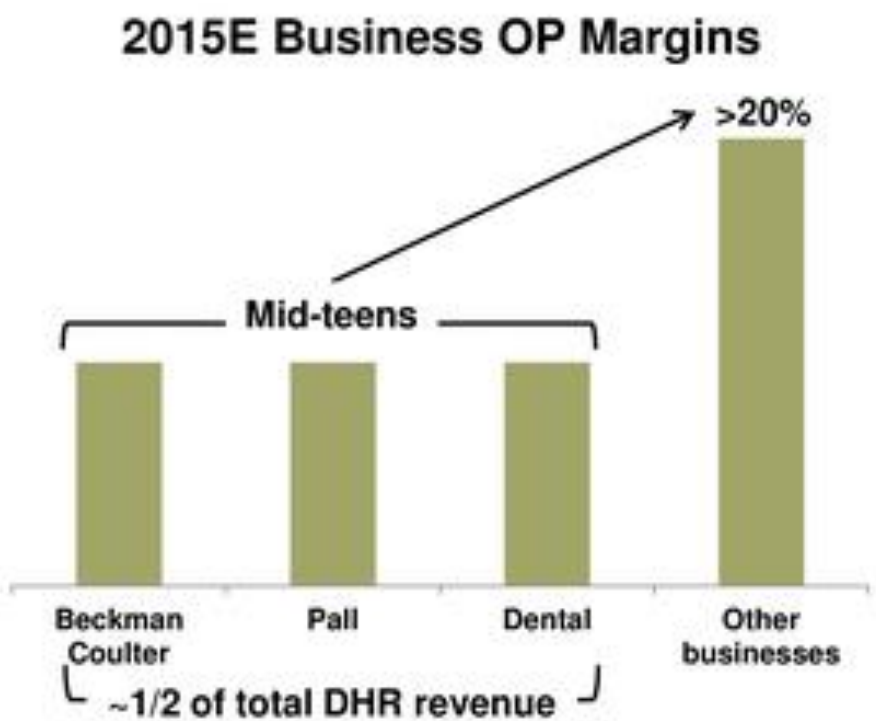
Danaher's Opportunity

	Revenue	Recurring Revenue*
Water Quality	$2.0B	55%
Product ID	$1.6B	40%
Life Sciences	$2.5B	50%
Diagnostics	$4.9B	80%
Pall	$2.8B	75%
Dental	$2.8B	60%
Danaher	$16.5B	60%

All revenue figures are aggregate for FY 2015E.
*As a percent of 2015E sales.



United by resilient business models with significant room to improve through DBS

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Dickson Sensaphone Remote Monitoring Systems

Fully-programmable environmental monitoring systems offer extensive on-site and remote monitoring capability to computer rooms, equipment rooms, remote facilities, small businesses, greenhouses, farms, and private homes.

- Monitor temperature, sound, humidity, water, and AC power failures (with optional optical sensors).
- Designed for desktop or wall mounting, the units are simple to install, program, and operate.
- No changes to standard electrical or telephone service are required. Systems feature an FCC-approved RJ-11 plug-in modular connector with 1.8m (6') cord.
- Once connected to a standard analog telephone line, the Sensaphone will respond to an alarm by dialing four (12444-050) or eight (12444-052) separate telephone numbers.

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SenseGrow

- Healthcare facilities are a delicate ecosystem where patient recovery is managed despite the pathogens that get introduced into the system. The most efficient way to control airborne pathogens is through maintaining positive and negative air pressures in the facility. With different pressure needs in critical care wards and operating rooms, hospitals protect their patients, staff and visitors from these pathogens. Any change in the air pressure requirement needs to be handled with utmost urgency.
- In addition to that, cleanrooms have a different set of requirements in terms of contaminants and particulate matter. Designating cleanrooms based on their level of cleanliness needs to be done within compliance levels to ensure safety.
- Healthcare facilities also deal with other operational challenges, such as backup generators and their maintenance while trying to lower their energy consumption.

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SenseGrow IIoT Platforms

With SenseGrow's Real-Time IoT Platforms, a variety of Remote Monitoring solutions can be built to not only provide a safe and clean facility for patients and staff, but also run healthcare operations efficiently. You can monitor

- Energy Usage
- Clean Rooms
- Chiller Temperature
- Air Quality
- Isolation/Critical Wards
- Backup Power Generators
- HVACs
- Hydrant Pressure
- Noise Levels
- Tracking Patient Movements

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ThermoFisher Wireless Monitoring for Cleanroom Laboratories

This wireless monitoring solution for laboratory equipment safeguards the integrity of precious samples by continuously monitoring critical parameters and securely logging data to provide unprecedented peace-of-mind. Featuring audit trail traceability, this solution assists with conformance to 21 CFR Part 11, and other strenuous regulatory requirements for labs operating in regulated industries. System features software, modules, repeaters, receivers, and a 915Mhz frequency (North America).

Continuous, 24/7/365 real-time monitoring of critical parameters, with intelligent data logging using globally recognized radio frequency transmissions; Temperature, Relative humidity, CO2 concentration, Differential pressure, 4-20 mA output, Alarm relay/dry contacts.

Easy-to-read display of monitored set points directly on module including audible/visual siren, telephone, email, text message, and fax.

Single solution that can grow with you to save time and money. Smart-Vue software can run one lab or an entire enterprise, whether across the street, or across the globe. Smart-Vue is easily expandable, allowing new equipment to be added to the existing systems. It's compatible with multiple brands and types of laboratory equipment. Easy to install, use, and maintain. Simple relocation–maintaining net work configurations–without the inconvenience and cost associated with rewiring

Smart-Vue protects the quality of your samples by continuously monitoring equipment conditions and will remotely notify you if conditions for sample integrity are compromised. In addition, Smart-Vue’s data logging capabilities assist with compliance to with FDA, GxP and other regulatory requirements.

Wireless monitoring, alerting you remotely in the event of a power or mechanical failure. Alert systems including real-time and visual alarms on the module. Configurable data-logging, transmission cycles and upper/lower limits. On-board single parameter module memory for up to 3,000 readings (1,500 + 1,500 for dual modules). Automatic alarms for out-of-bounds conditions and technical problems. Easy-to-read LCD display with latest reading, alerts, signal strength and battery level. Fully integrated with Smart-Vue Client /Smart-Vue Server software suite. 3.6V Lithium, replaceable battery (3600 mA). Mounting kit with plastic holder, magnet,screws, cable ties, plastic cable holders and Velcro™ fasteners. Smart-Vue wireless monitoring solutions are available for both USB and network receivers.

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TSI Continuous Monitoring Systems for Cleanrooms

For Pharmaceutical, Medical Device and Life Science industries, ensure compliance to EU GMP Annex 1 and the aseptic processing FDA cGMP with TSI's continuous monitoring systems. For Electronics applications, optimize throughput with particle monitoring and SPC tools. In addition, TSI's Facility Monitoring Systems offer:

- FMS Software with open architecture
- Flexibility to integrate with any manufacturer of environmental sensors
- Ability to comply with FDA cGMP and EU GMP Annex 1
- Complete system validation tools
- Optional built-in system redundancy
- Statistical SPC tools for electronic applications
- Simple system maintenance and calibration
- TSI's Continuous Monitoring Systems are integrated, installed, and serviced with the local support from a worldwide network of qualified representatives, ensuring aht the system stays up and running.

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TSI has New Wireless Velocity and Pressure Measurement Solutions

AirPro Instruments are revolutionary wireless velocity and pressure measurement solutions that maximize productivity by offering easier measurement access, unmatched accuracy, seamless multi-data reporting and a user-friendly interface for fast, intuitive operation.

In the near future, TSI will be releasing a series of instruments for this new platform. The first series includes a Velocity Meter (Model AP500) with a suite of plug-and-play probe options, and Micromanometer (Model AP800) . These devices interface with the TSI-developed AirPro Mobile Application Software with configurable feature sets, to meet customer needs. The AirPro Mobile Application Software supports Android and iOS operating systems.

Advanced and Professional Feature Sets within the AirPro Mobile App eliminate the need for manual steps and hand-written documentation, by recording measurement calculations and logging data. Users can easily share measurements, photos and comments that can be exported into reports, saving you time on the job site.

"The new AirPro Instruments solution continues a long TSI tradition of designing highly accurate instrumentation for HVAC professionals worldwide," said Jim Schumacher, product specialist for ventilation test instruments at TSI. "By combining trusted instrumentation to wirelessly communicate with everyday smart devices based on Android and iOS operating systems, measurement efficiency and reporting capabilities will significantly increase."

This new solution will offer service through license and probe management, extended service contracts and advanced probe replacements, eliminating downtime. Although designed exclusively for wireless applications, AirPro Instruments do not compromise on the high reliability, accuracy, and overall performance

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Cleanroom Garment Management and other Onsite Services from VWR

VWRCATALYST onsite services and technology help streamline procurement, optimize inventory levels, and spend less time managing your lab supplies. So the operator can reduce costs and focus on science.

- Point-of-Use Inventory Management: Through Lean supply chain management, we stock frequently used laboratory consumables in the right amounts, at the right locations. This can be done at convenient points of use or other stocking locations.
- Shipping, Receiving, and Mailroom Support: Support with shipping of products (non-biological or chemical), receiving and checking of inventory, and performing security checks on mail for delivery to end users.
- Garment Management Services: Management of cleanroon and laboratory coat items, including bar-coding for traceability and maintaining adequate supply. VWRCATALYST can work with or manage a third-party provider for this service.

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