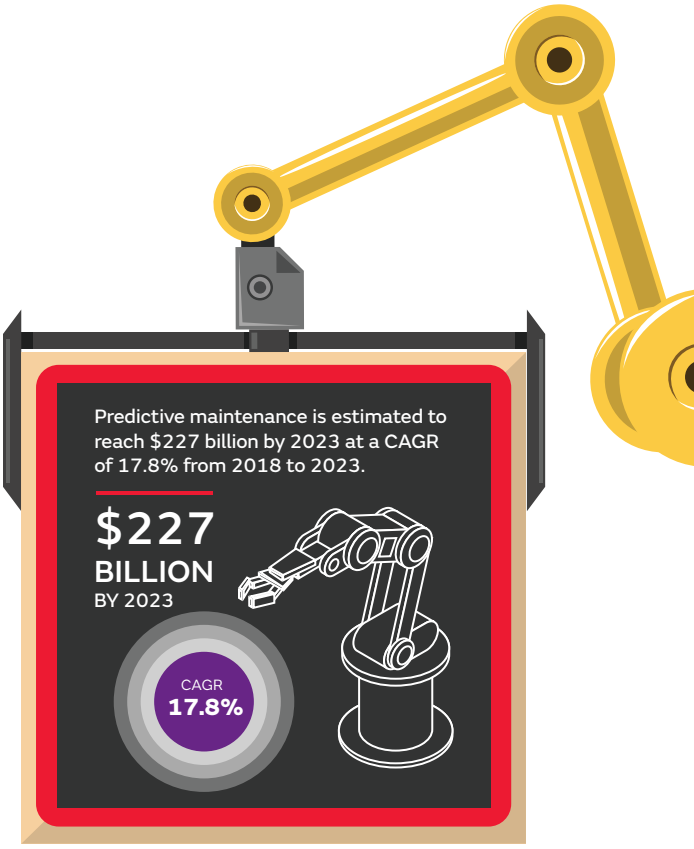
Market Insights on
Smart Factory Automation

muRata
INNOVATOR IN ELECTRONICS

Executive Summary

Smart Factory Automation is revolutionizing manufacturing, creating an ecosystem of devices and applications to optimize operational efficiency, increase worker safety, prolong machine lifespan and minimize production downtime.



Smart Factory Automation applications such as predictive maintenance, real-time monitoring, cognitive processes, operations management, industrial communication, tracking and programmable logic controllers, enable manufacturers to gain better visibility over their people, processes, machines and products, whilst increasing productivity, maximizing profitability and reducing manufacturing defects. The Global Smart Factory Automation Market is forecasted to reach $994 billion by 2023 and predictive maintenance is a critical component, forecast to reach $227 billion by 2023 at a cumulative growth rate of 13.3% and 17.8% respectively.

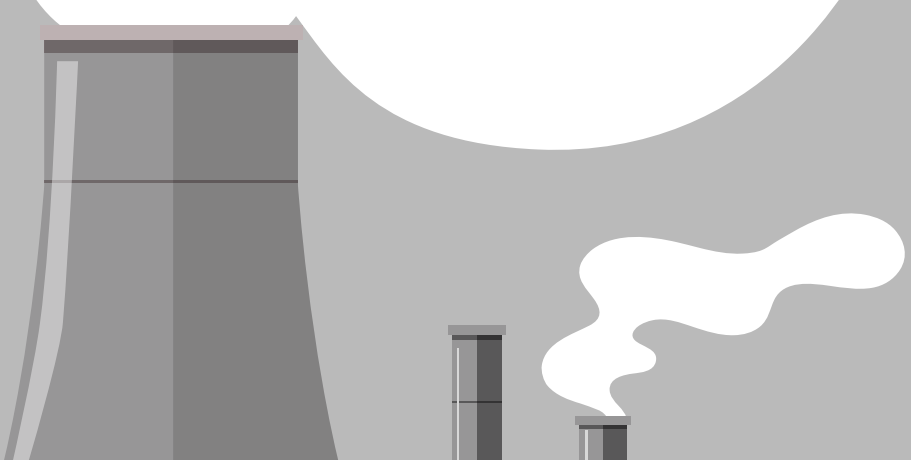
Demand for predictive maintenance in automated manufacturing is rising due to its potential to reduce imminent risk of failures, minimize downtimes, and prolong equipment lifespan. Smart manufacturing simplifies maintenance process by applying advanced data analytics with condition monitoring for consumables, wear-and-tear, and performance. These data are translating into actual cost-savings for manufacturers and eliminating the need for labor-intensive, imprecise manual checking methods.

In real-time monitoring, sensors are attached to machines actively detecting and obtaining data on the condition and environment of workers, vehicles, machinery, and facilities accurately. They also track the levels of consumables such as lubricants or refrigerants, as well as their temperature, viscosity and other variables. Powered dashboards gather and analyze data, promptly sending alerts to person-in-charge if a change is detected, so that corrective actions can be taken immediately. Detailed downtime analysis and failure reports on key machines, components or process constraints are generated for a holistic view of future maintenance needs, enabling manufacturers to reduce the mean times between failures and repairs.

Smart Factory Automation is the future in gaining a competitive edge in today's fast-paced manufacturing environment. Predictive maintenance is poised to become an indispensable tool in driving Industry 4.0, paving the way towards making manufacturing more efficient, smarter, and safer.

> *"Smart Factory - the future in gaining a competitive edge in today's fast-paced manufacturing environment."*

Contents



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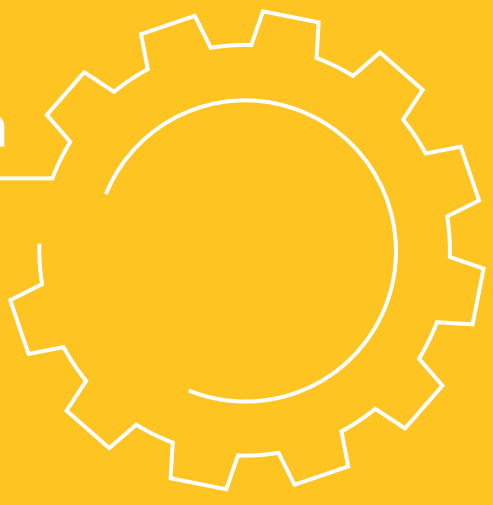
Introduction to **Smart Factory Automation**



Introduction of Smart Factory Automation

Smart Factory is a highly digitized and connected production facility that employs IoT enabled sensors, predictive analytics, modeling, big data and other advanced automation technologies to improve manufacturing efficiencies. It is also commonly known as 'Industry 4.0'.

Key Applications

Predictive Maintenance

One of the maintenance strategies where application of predictive analytical algorithms against real-time data is used to proactively identify areas of potential concerns and to provide suitable solutions to address the issue.

Integrated IT Systems

Integrated IT Systems facilitates end-to-end system visibility between business systems and operational systems. In a smart factory, this facilitates integration of shop floor decision with the rest of the supply chain processes.

Production Automation

Objectives of production automation is to improve the efficiency of labour and quality of manufactured products, and to create suitable conditions for optimum utilization of existing resources. Degree of automation in a factory can vary from partial, integrated to total automation.

Resource Efficiency

Resource efficiency refers to maximizing inputs such as materials, people, other assets (such as smart meters, smart lighting, etc.) to minimize cost and waste.

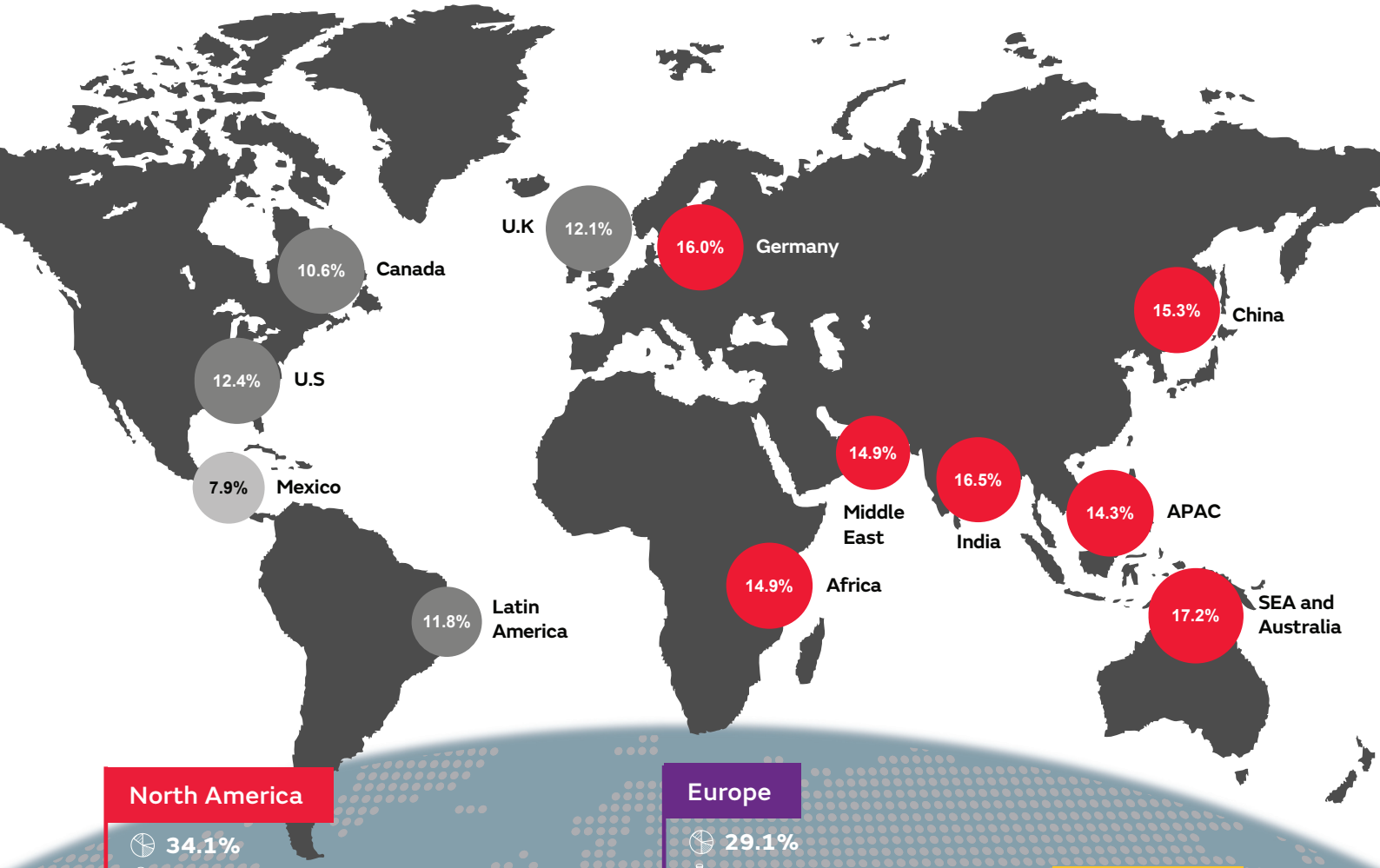
Source: Frost & Sullivan Analysis

Global Smart Factory

Automation in Manufacturing Market

By Geography

- (>14% CAGR) Emerging Markets
- (10-14% CAGR) Matured Markets
- Underdeveloped Markets



North America
34.1%
11.95%

Europe
29.1%
13.74%

Asia-Pacific
24.2%
14.33%

LAMEA
12.6%
13.82%

Market Share (2018)%
CAGR (2018-2023)%

Source: Industrial Reports, Frost & Sullivan Analysis

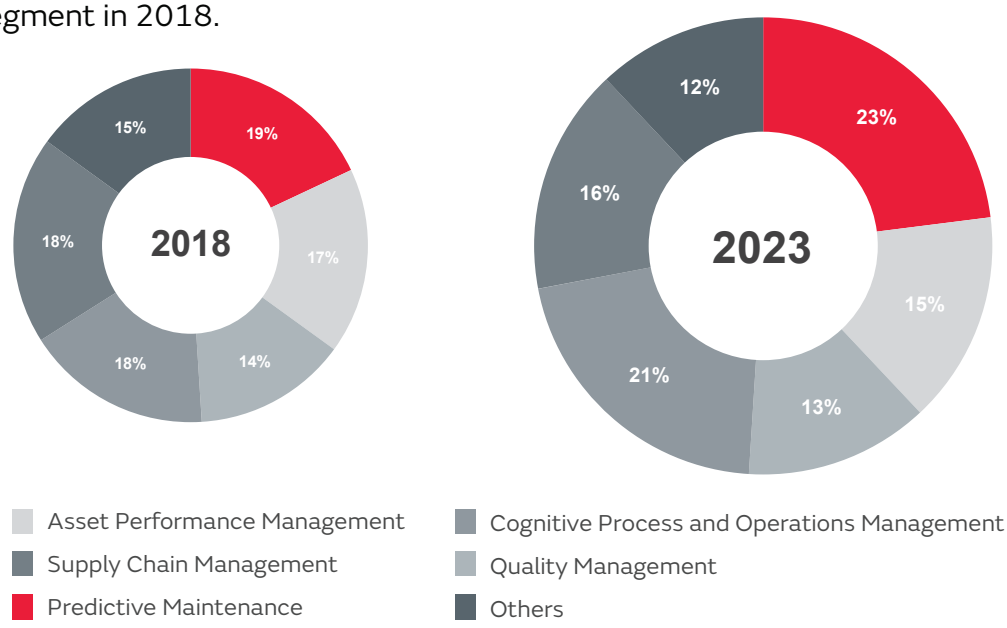
Global Smart Factory

Automation in Manufacturing Market

Global Smart Factory Automation In Manufacturing Market, Growth Projection (2018 vs. 2023)

The Global Smart Factory Automation in the manufacturing market by application was $533.0 billion in 2018 and is projected to grow at a CAGR of 13.3% to reach $994.0 billion by 2023. On average, companies are expecting cost savings between 15% to 20% from the deployment of Smart Factory Automation solutions. The level of cost savings achieved is just a couple of percentage points lower than expected.

North America and Europe accumulate to a total of about 63.9% of the Global Smart Factory Automation market in the predictive maintenance segment in 2018.



Source: Industrial Reports, Frost & Sullivan Analysis

Predictive maintenance is the most sort after application in Smart Factory Automation. Broadly, case studies are related to ***Predictive Maintenance Asset Performance Management and Quality Management*** as they are going to contribute more than 50.0% of the Global Smart Factory Automation revenue.

Global Smart Factory

Automation In Manufacturing Market

By Application

Application	Market Size (2018)	Market Size (2023)	CAGR (2018-2023)
Predictive Maintenance	*$100 Billion*	*$227 Billion*	*17.8%*
Asset Performance Management	$89 Billion	$145 Billion	10.3%
Quality Management	$72 Billion	$133 Billion	13.1%
Cognitive Process and Operations Management	$94 Billion	$208 Billion	17.2%
Supply Chain Management	$98 Billion	$162 Billion	10.6%
Others	$80 Billion	$119 Billion	8.3%

Source: Industrial Reports, Frost & Sullivan Analysis

Supply chain management is the highest contributor with $89.0 billion in 2018; however, predictive maintenance is estimated to reach $227.0 billion by 2023, growing at a CAGR of 17.8%, from 2018 to 2023. The overall market is anticipated to reach 47.7% by 2023, owing to high market growth over the next seven years. Predictive maintenance is expected to grow at a lucrative rate of 17.8% during the forecast period (2018-2023).

North America was the highest contributor with $164.0 billion in 2016 and is estimated to reach $320 billion by 2023, growing at a CAGR of 11.8% from 2018 to 2023.

The increase adoption and maturity of cloud, sensors technologies and pervasive use of analytics is expected to drive Smart Factory Automation adoption.

Drivers

Real Time Asset Monitoring

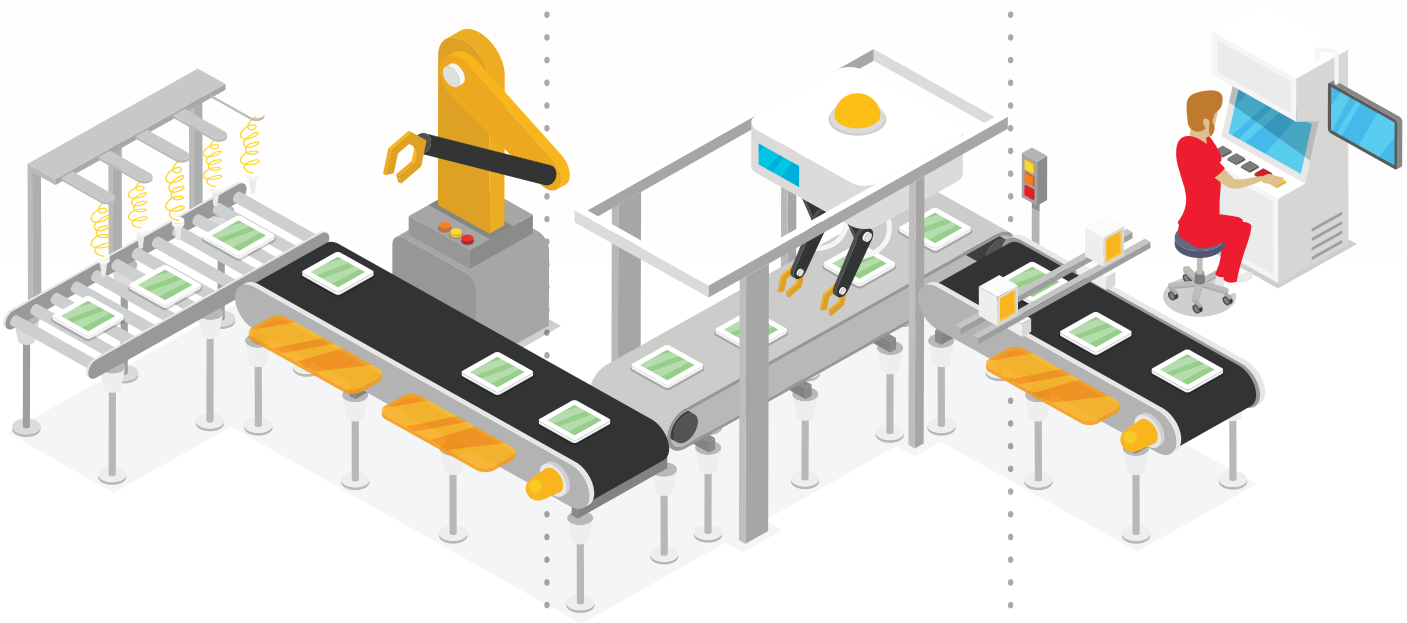
Real time asset monitoring has increased drastically specially in the manufacturing industry. The ability to instantly notify users of any safety or delivery shortcomings.

Low Cost of Ownership

Integration of smart sensors into industrial machines has increased cost efficiency by 50% and is expected to increase savings further.

Need to Lower Cost and Improve Efficiency

The advent of adapting to Smart Factory Automation via connected devices has enabled manufacturers to lower resource consumption and increase productivity.



Opportunities

Technological Maturity Growth

The digital age has redefined factories with 86% out of 2000 factories expect to see cost reductions and revenue gains through the digitization in Smart Factory Automation.

A Connected Operational Intelligence

Manufacturers get a bird's eye view of production to minimize manufacturing defect by leveraging Smart Factory Automation in production and operations.

Adoption of Cloud-Based Deployment Model

Leveraging cloud based services in the manufacturing industry across the APAC region is among the various Smart Factory Automation solutions that manufacturers are opting.

Key Challenges to Implementation

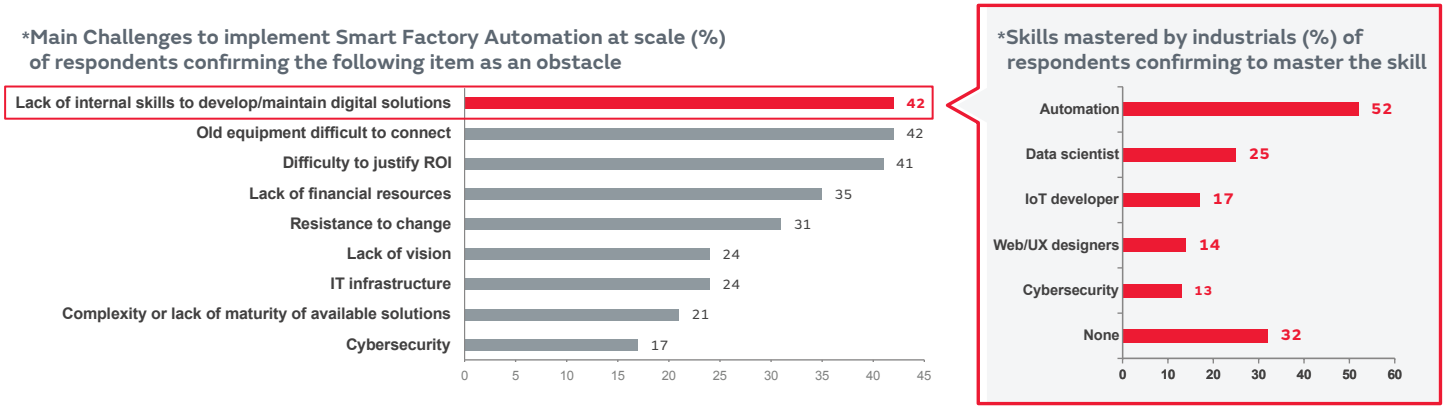
The greatest challenge facing manufacturers large and small concerns the issue of human capital, rather than hardware or smart-robot deployment.

Nearly half the respondent companies point to a lack of both hard and soft internal skills to make the transformation happen fast.

Roughly a third say they lack competency in many key areas, including operation technologies, data, cybersecurity, systems integration, and change management. To tackle this hurdle, more than 70.0% said they are developing their operating model together with partners, including IT companies, startups, and academics.

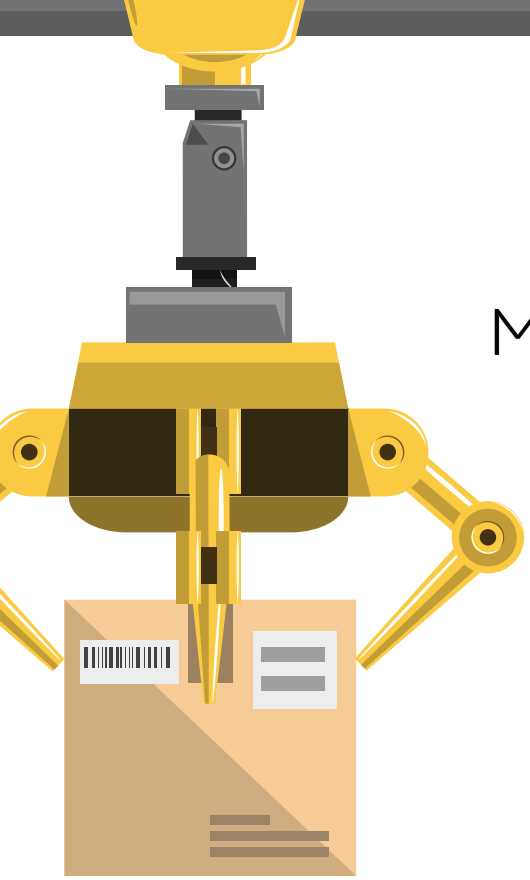
Another key roadblock facing industrial directors is the need to make the return on investment (ROI) case for what is certain to be a costly investment, especially at companies with more than 1,000 employees. Getting an overarching view on ROI is a prerequisite for the transformation.

Main Challenges to implement Smart Factory Automation



***Note:** Results above are based on the Oliver Wyman and L'Usine Nouvelle online survey conducted between August and September 2017, with industrial firms.

Source: Frost & Sullivan Analysis

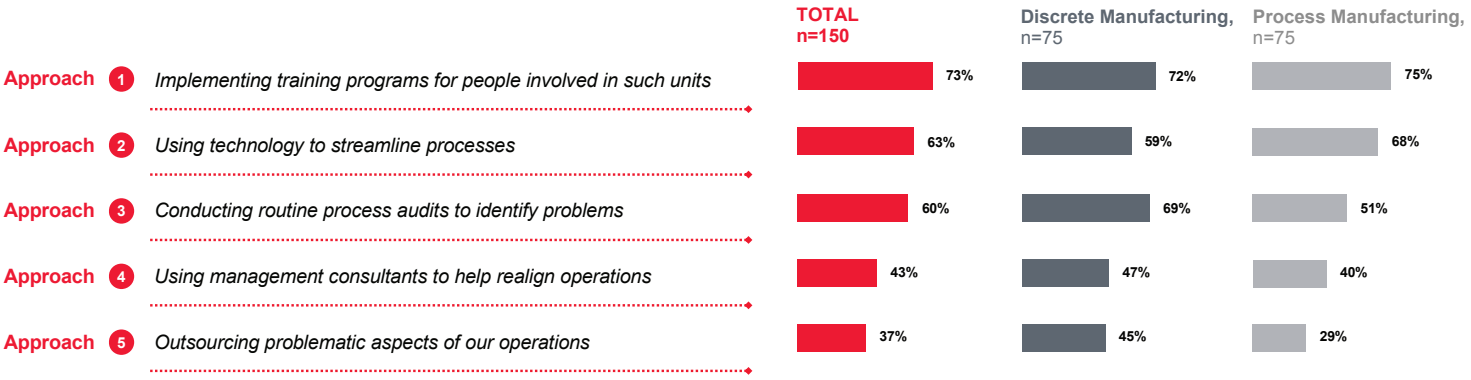


Approaches to Overcoming Managing Operational Challenges

From an operational management perspective, quality control and supply chain management were identified as the most challenging areas. More manufacturers within the discrete segment identified quality control as the most challenging issue while supply chain management was the number one issue in process manufacturing.

The fact that discrete manufacturing such as automotive involves complex supply chains comprised of hundreds of vendors providing varying components is likely to explain the greater focus on quality control. From a Smart Factory Automation solution provider's perspective, this is a somewhat challenging area that has received much less attention, to date, compared to other Smart Factory Automation solutions such as those that focus on fixed and mobile asset management or logistics. Substantial differences exist between discrete and process manufacturing firms in the way they address their operational challenges.

While employee training programs are considered a leading solution by both discrete and process manufacturing organizations, 68% of firms in process industries stated using technology to streamline processes compared to 59% in the discrete segment. Similarly, a higher percentage of firms within discrete industries rely on routine process audits versus those in process manufacturing.



***Note:** This above results are based on Frost and Sullivan survey conducted in 2017, with industrial firms.

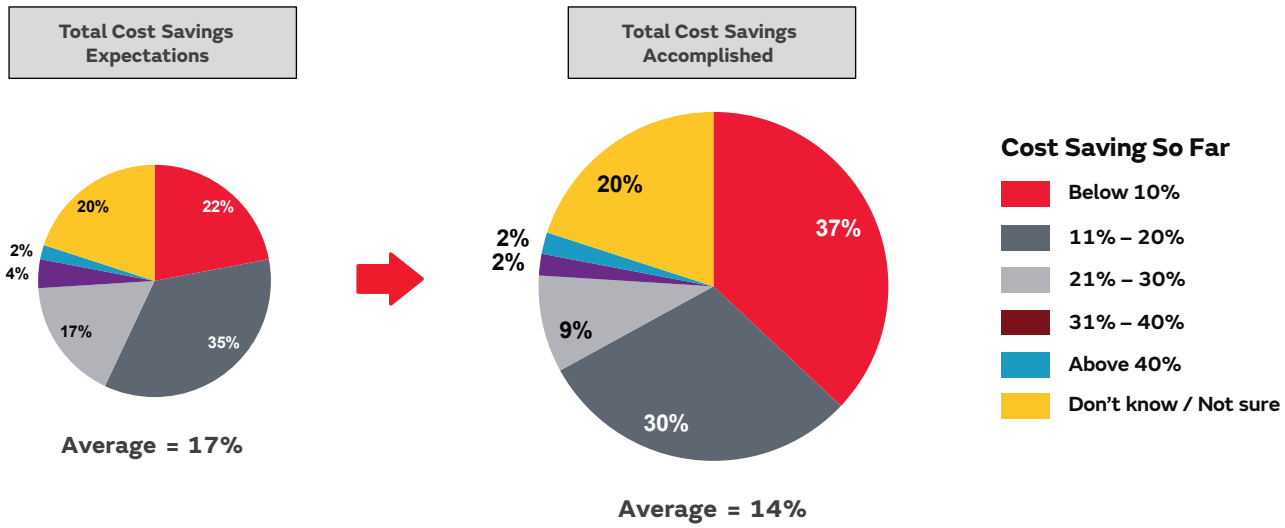
Base: All respondents (n=150)

Q. Which of the following describes your organization's overall approach toward the most challenging aspects of your manufacturing operations?

Source: Oliver Wyman, Frost & Sullivan Analysis

ROI: Return on Investment

Smart Factory Automation-related Cost Savings Expectations and Actual Savings



***Note:** This above results are based on Frost and Sullivan survey conducted in 2017, with industrial firms.

Base: Respondents in organizations that have implemented Smart Factory Automation solutions (n=46).

Q. Please tell us about the post-implementation cost-saving goals/objectives that your organization established for smart Smart Factory Automation solution deployments.
Q. How much overall cost savings have you actually accomplished from deployment of Smart Factory Automation solutions for manufacturing?

Source: Oliver Wyman, Frost & Sullivan Analysis

On average, the difference between expected and accomplished operational cost savings from the implementation of Smart Factory Automation solutions is less than 5 percentage points for firms that have deployed such technology.

At the total level, 57% of the organizations that have adopted Smart Factory Automation aspired to realize up to 20% in cost savings while the other 23% expected a higher rate. On average, the respondents aspired to have 17% cost savings over their pre-Smart Factory Automation operational expenditures; however, the average actual cost savings accomplished was reported 14%. Given that the average lapsed time since Smart Factory Automation implementation is below 3 years, a 14% cost saving is rather substantial and one that offers strong justification for Smart Factory Automation deployment.

In addition, the intangible benefits of Smart Factory Automation implementation go well beyond cost savings in that such solutions offer greater operational control, effective collaboration with members of the value chain, and potentially higher employee productivity.

87% of the respondents achieved a cost saving of 11 - 40%. In discrete manufacturing, 31% of respondents achieved cost saving of 11-20%. 59% of the respondents accomplished cost saving of more than 10% in discrete manufacturing.

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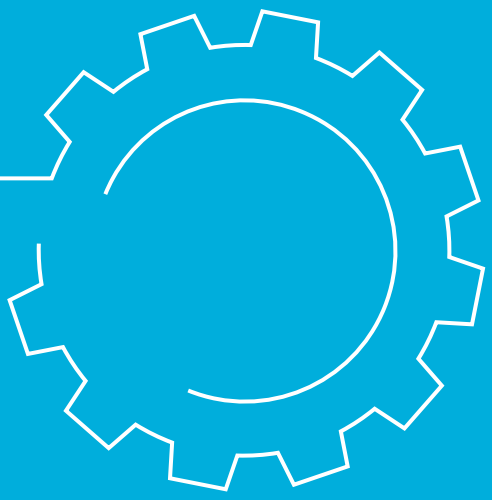
Case
Studies



Case Study 1:

Work in Progress (WIP) Monitoring for PCB

Problem Overview

Due to competition electronic manufacturers are forced to reduce the cost of components and increase revenue through production efficiency, quality improvement, and outsourcing.

The assembly of a large number of models requires flexible manufacturing processes and better accuracy for lead times. Companies are trying to limit the scope of product recalls and comply with more regulations.

Solution / Service Description

The tracking and traceability solution using RFID chip technology to program product and manufacturing information directly onto the PCB.

The programmable data includes serial number, model number, manufacturing process and other customizable individual product information.

The information can be securely accessed and updated at any point in the manufacturing, shipping or repair processes.

Implementation Overview

The off-the-shelf solution provides automated real-time visibility and maintains complete electronic pedigree for traceability on parts and WIP providing real-time dashboards, alerts and reports for the shop-floor management.

The RFID tag is mounted onto the PCB as a standard SMT (surface mounted technology) component.

The manufacturing information can be automatically programmed into the RFID tag for rapid access to critical data without the need to be connected.

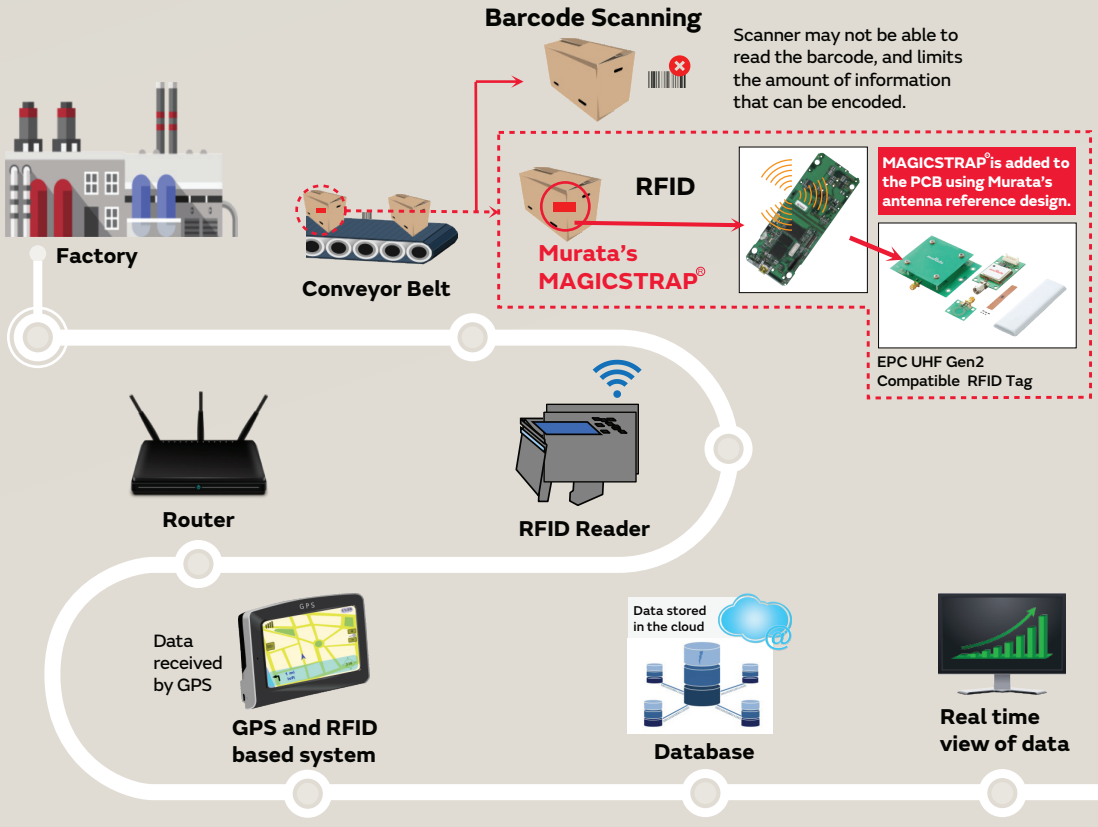
Challenges

Tracking Printed Circuit Boards (PCB) using barcodes requires line of sight between the label and the reader (i.e scanner) may not be able to read the barcode, and limits the amount of information that can be encoded.

Even two dimensional barcodes have significant challenges including costs of readers and accuracy of reads.

High-density boards have little real-estate available for barcodes which cannot be read simultaneously by a single barcode reader.

Printed Circuit Board (PCB) with RFID Tracking & Traceability



Key Benefits

- PCBs can be uniquely identified for a single PCB or bulk inventory taking.
- Additional data can be written on the RFID chip.
- Hardware and firmware versions, dates, test status, QC records, etc.
- Data can be password protected or permanently locked.
- Short and long range read distances are possible.
- RFID chip also readable through product enclosure.

Case Study 2:

Predictive Maintenance for Motor

Problem Overview

The industrial equipment and machines have rotating part. These parts generate distinctive patterns and level of vibrations. As the flow vibration is interrupted, excessive noise and shaking signal a problem or deterioration in the machinery.

Solution / Service Description

A vibration sensor is mounted on the motor which detect vibrations in motor.

Murata's 1 axis digital accelerometers collect information from one axis on both ends of the motor. It measures low to very high frequencies.

The sensor is used to quantify the magnitude of vibration known as vibration amplitude, and surface temperature. In other words, it reports how smooth or rough the machine is running.

Implementation Overview

In case of the stator winding, sensors are placed as close as possible to the hottest part.

By tracking and recording temperature trends, plant managers come to know when machine parts are running hot enough to cause issues, and will then be able to address those issues before they lead to catastrophic failure.

The data is transferred through data analytic devices by manual or wireless connection.

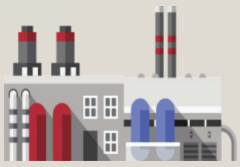
Challenges

Client was facing problem related to rotating machinery.

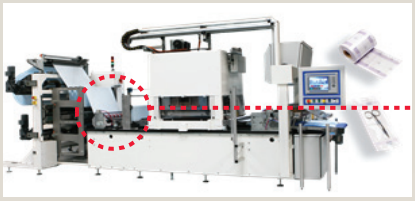
When the rotating flow is interrupted, excessive noise and shaking signal a problem in the machinery.

There are some other issues which cause motor failure, such as unbalance, misalignment, sleeve-bearing problems, resonance issues, and over-heating, etc.

Real-time Motor Handling Using Predictive Maintenance



Factory



Production Line

Wireless Network

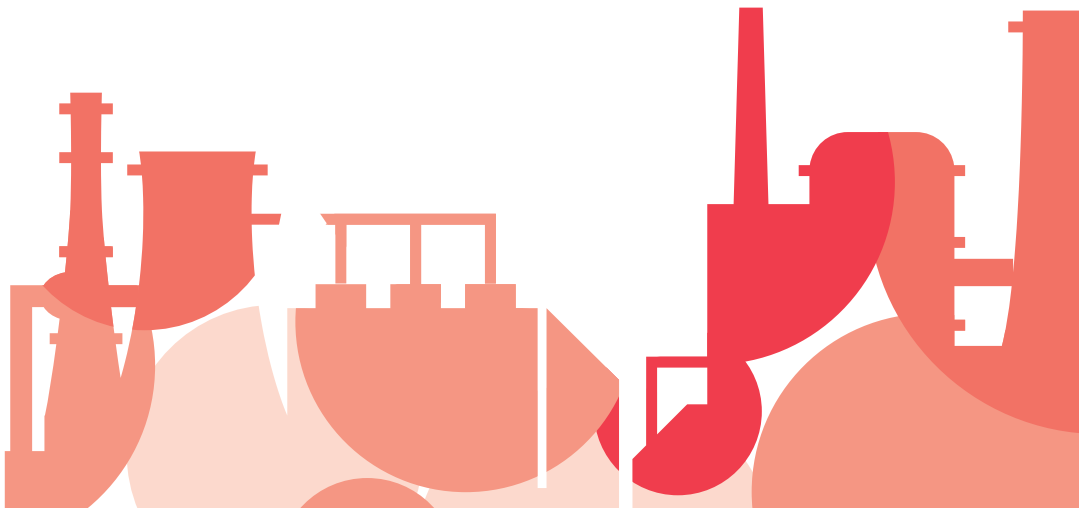
Data from sensors is transmitted by wireless connections.

Predictive Maintenance

The user looks at the measurement coming off of the sensors and read across the chart to get an exact number. This is an indication as to whether machinery is operating in an area where damage is likely to occur or things are running perfectly.

Key Benefits

- Longevity of industrial machinery.
- Help to identify the specific cause and location of a problem, reducing maintenance costs and equipment downtime.



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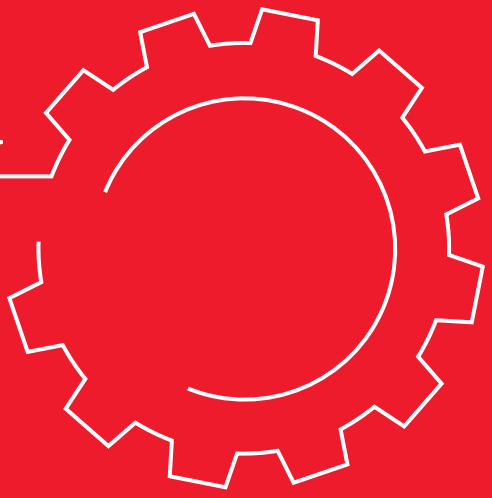
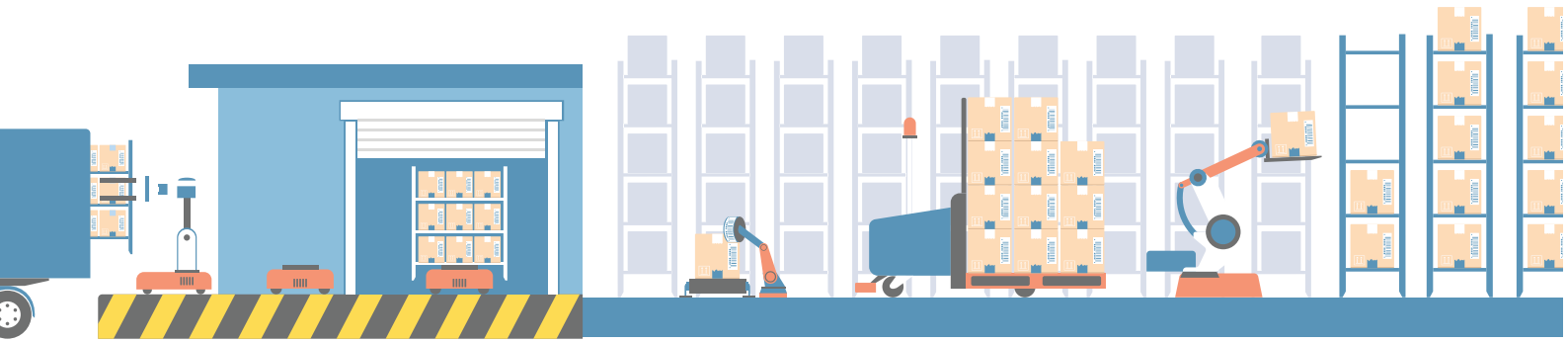
Enabling Smart
Factory Automation - Murata



Murata -

Forefront of Building Smart Manufacturing Solutions

As one of the global leaders in the design, manufacture and supply of advanced electronic materials, electronic components and multi-functional, high-density modules, Murata is at the forefront of building Smart Factory Automation solutions. With deep expertise in deploying Smart Factory Automation solutions for manufacturing sectors, Murata is a trusted partner in supporting manufacturers to migrate seamlessly to the Smart Factory Automation implementation. Smart Factory Automation is the future in gaining a competitive edge in today's fast-paced manufacturing environment. Predictive maintenance is poised to become an indispensable tool in driving Industry 4.0, paving the way towards making manufacturing more efficient, smarter, and safer.

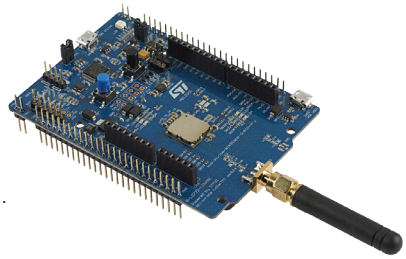


Our Technologies

Connectivity: LPWA Solution

Low Power Wide Area (LPWA)

Murata is displaying communication modules incorporating LPWA communication standards, which combine extended-range data transmission and decreased power consumption. From process management to logistics and warehouse management, LPWA technology offers diverse applications for Smart Factory Automation.



Related Link

Solution *www.murata.com/en-sg/products/lpwa/lora*

Product *www.murata.com/en-sg/products/lpwa/lora#lora3*

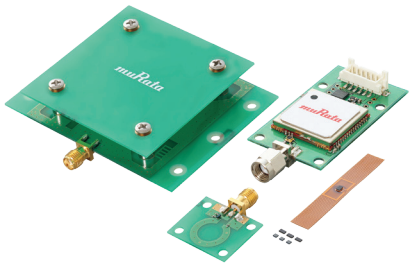
Video *www.murata.com/en-sg/support/library/video#LPWA*

Solution Product Video

RFID Solution

Work-In-Progress Monitoring with RFID Technology

RFID technology will play a major role in future smart factories, enabling devices to communicate in real time via radio waves with manufacturing systems hosted on the cloud. Murata offers solutions for smart factories, logistics and human management that connect things in factories (products, production equipment, etc.) to the Internet for higher industrial efficiency and new business creation.



Related Link

Solution *solution.murata.com/en-global/service/rfid-solution/*

Product *www.murata.com/en-sg/products/rfid/rfid/uhf/smd*

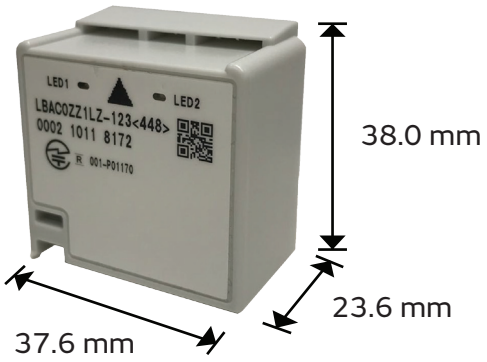
Video *www.murata.com/en-sg/support/library/video#rfid*

Solution Product Video

Vibration Sensor

Predictive Maintenance with Vibration Sensor and Gateway

Murata offers a device for monitoring vibrations and surface temperatures in critical rotating machines and other industrial machinery. An embedded processor in the sensor node sends data wirelessly via a gateway. The wireless vibration sensor node and gateway support signal measurement, data provision, etc. for diagnostic purposes and predictive maintenance, such as early detection of machine breakdown, reduced engineering labor and maintenance costs, minimized downtime, and improved operational reliability and worker safety.



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Product Video *www.murata.com/en-sg/campaign/ads/asean/2019/sfa*

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Murata S. E. Asia & India Network

Murata Electronics Singapore (Pte.) Ltd.
(Regional Management Company)
200, Yishun Avenue 7,
Singapore 768927
Tel: 65-6758-4233 **Fax:** 65-6753-6627

Murata Electronics (Malaysia) Sdn. Bhd.

Penang Branch
Unit 6.03, Menara Boustead,
39 Jalan Sultan Ahmad Shah,
10050 Penang, Malaysia
Tel: 60-5-362-9389 **Fax:** 60-4-229-4257

Kuala Lumpur Branch
Suite 13.01, Level 13, Menara IGB,
No.1 The Boulevard,
Mid Valley City, Lingkaran Syed Putra,
59200 Kuala Lumpur, Malaysia
Tel: 60-5-362-9390 **Fax:** 60-3-2287-7569

Murata Electronics Philippines, Inc.
Panorama Building, No.5 & 6 South Science Avenue
Laguna Technopark, Sta Rosa,
Laguna 4026, Philippines
Tel: 63-49-540-7310

Thai Murata Electronic Trading, Ltd.
Thaniya Plaza Building,
10th Floor, 52 Silom Road,
Suriyawongse, Bangrak,
Bangkok 10500, Kingdom of Thailand
Tel: 66-2-036-0000 **Fax:** 66-2-036-0099

Murata Electronics (Vietnam) Co., Ltd.
Room 501, 5th Floor, V Building,
125-127 Ba Trieu Street, Nguyen Du Ward,
Hai Ba Trung District, Hanoi, Vietnam
Tel: 84-24-3637-4666 **Fax:** 84-24-3632-1118

Murata Electronics (India) Private Limited
No.8-A, 8th Floor, Capitale, 554/555,
Anna Salai, Chennai - 600 018, India
Tel: 91-44-6693-0300 **Fax:** 91-44-6693-0318

Delhi Branch
Unit No. 107, 1st Floor, Vatika City Point,
M.G. Road, Gurgaon - 122 002, India
Tel: 91-124-662-2500 **Fax:** 91-124-662-2506

Bangalore Branch
Ground Floor, Nitesh Timesquare, No.8,
M.G. Road, Bangalore - 560 001, India
Tel: 91-80-4669-3700 **Fax:** 91-80-4669-3778