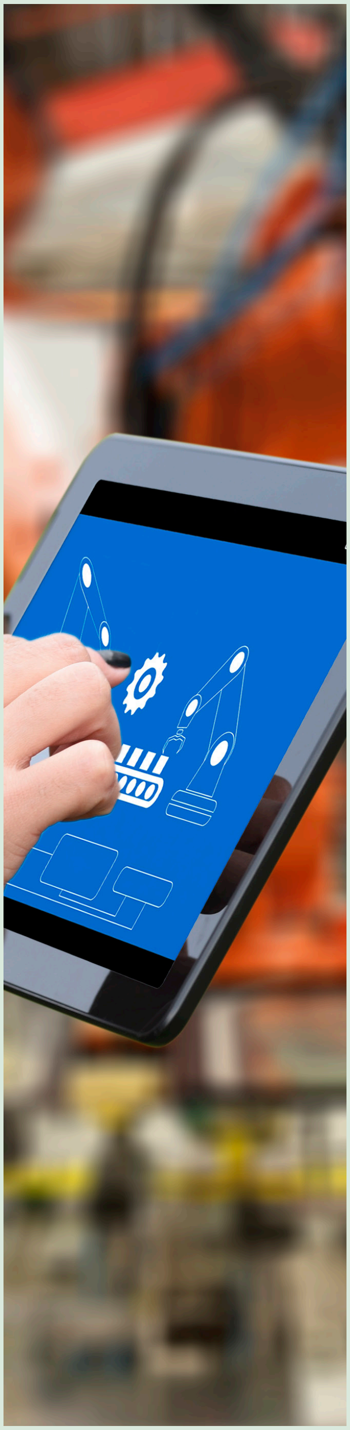
WHITE PAPER



THE IOT VALUE MAP FOR MANUFACTURING

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Abstract

The Internet of Things is a powerful transformative technology of our times. However, its transformative capabilities need to be understood in the context of specific business scenarios and the expectations tuned accordingly. This paper takes a Value Map approach towards identifying the IoT use cases for the manufacturing industry and discusses how some of the key challenges that a manufacturer's Value Map functions face today, could be overcome by using IoT.

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1. Introduction

"It was the best of times; it was the worst of times…." the famous opening lines of 'A Tale of Two Cities' could not have more aptly described the present times that we find ourselves in. One of the best times for humankind in terms of living standards, life expectancy, poverty alleviation and technology, has been brought by a pandemic to a grinding halt of the kind not seen since World War II. The 'disruption' that has been the hallmark of technology of our times, has been met by disruption of a totally different kind – each leaving its mark in totally opposite ways on people from all walks of life, economy and society, and on a truly global scale.

While disruptions have varied manifestations in terms of industry segments, a theme consistent of all disruptions is - they force a rethink on existing ways of doing business and resource allocations. They usually carry the power to overhaul or change competitive positions fundamentally. A study of the history of industrial disruptions tells us that efficiency and productivity improvements are usually the positive outcomes of such events. Enterprises that have looked at disruptions as an opportunity and have challenged themselves to enhance their capabilities and competencies have created for themselves new competitive advantages.

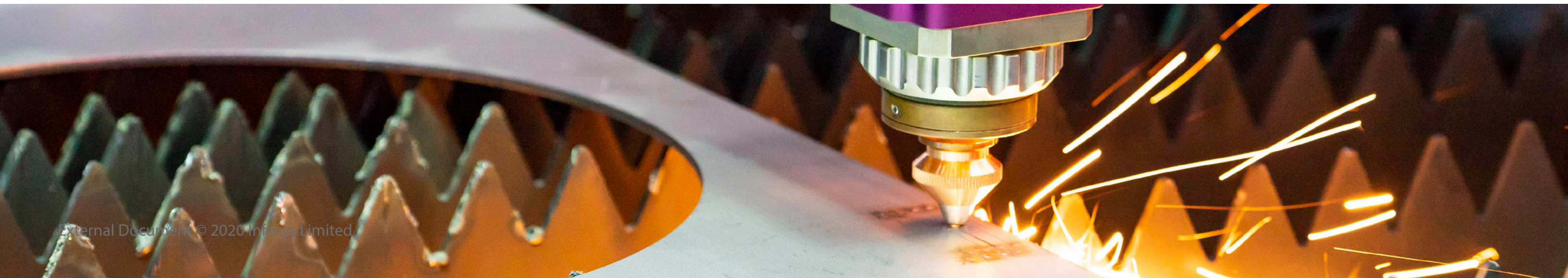
The connected world that is today becoming increasingly flatter owing to convergence of data, devices and platforms, has changed the way companies operate, manufacture and interact with their customers. The breakneck speed of technological innovations of the recent years has been fueled primarily by a rapid decline in cost of storage and a rapid rise in computational power and speed of networks. Big Data, Cloud technologies, Sensors technologies and Analytics have flourished due to these changing hardware and network economics and have become the pillars for technological transformation of industries. These have enabled 'Digital twins' of physical objects to interact with each other, in an ecosystem called the Internet of Things (IOT).

Figure 1 Internet of Things, Connected & Communicating

"…Internet will disappear. There will be so many IP addresses, so many devices, sensors, things that you are wearing, things that you are interacting with, that you won't even sense it. It will be part of your presence all the time. Imagine you walk into a room, and the room is dynamic. And with your permission and all of that, you are interacting with the things going on in the room."

Eric Schmidt, Google Chairman

IoT is an exciting new technological ecosystem, and as per latest research, a mind boggling 75 billion devices are estimated to be connected to the Internet of Things by 2025.[1] The impact of such changes has been felt like no other in the manufacturing industry which is undergoing the fourth industrial revolution- also called the Industry 4.0. The global spend in IoT in manufacturing is expected to grow to $45.3 billion by 2022 at a 5-year CAGR of 29%.[2] While the pace of adaption to this new paradigm varies drastically among manufacturing companies by segment, type and geography, a 2019 survey of 3000 decision makers identified a 87% manufacturing industry adoption of atleast one IoT project in either planning phase or beyond.[3]



However, economic disruptions impact revenues and margins thereby putting pressure on resources available to a company. This constrains available capital and makes resource allocation decisions tricky. Reduced capital and resources are first allocated to keep the wheels rolling for the core value generating activities such as marketing, production and sales. However, the nature of manufacturing today is such that companies need to continually invest in transformative technology - in many cases such transformation is required not to lead the pack, but merely to stay abreast with competition.

As incremental dollar allocation to technology comes under intense scrutiny, there is a clarion call to justify such spending with measurable, defined benefits. Benefits that are not several time periods away, but those that are of more immediate nature- realizable in months and quarters. More than ever, businesses will now have to justify technology projects through the prism of economic value created for the enterprise.

As with any new major technology, it takes time for the smoke to clear and for the real expectations and returns to be realized. Similarly, IoT- which is not just one technology, but an ecosystem of many technologies coming together, requires careful analysis by manufacturers to identify the use cases specific to their business, that could be transformed by IoT. In doing this analysis, attempt must be made to create an approach through which IoT use cases are selected that deliver an immediate impact for the enterprise as well as create success stories. The increasingly valuable technology dollar then needs to be directed to those use cases only.

This paper proposes that identifying the Manufacturing Value Map and using IoT to address the challenges around the Value Map, is an approach that manufacturers should adopt to deliver IoT driven business benefits. A list of such use cases is discussed in details for the manufacturers to select from.

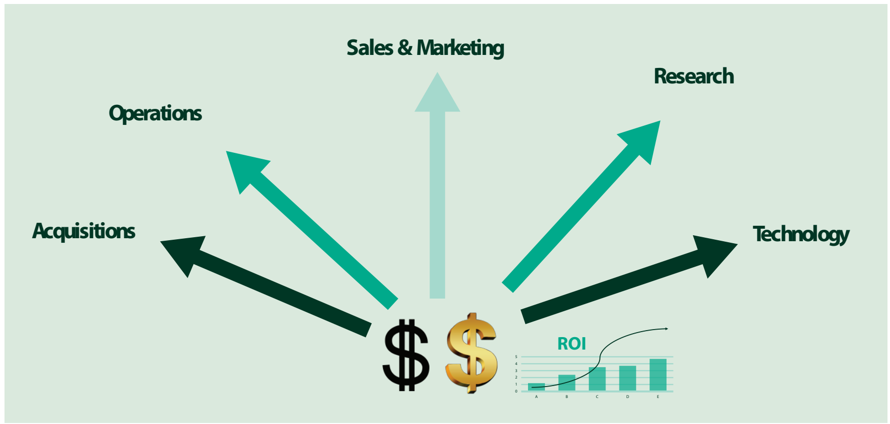


Figure 2 Resource Allocation guided by measurable ROI

2. Defining the Value Map

A Value Stream is defined as "….the sequence of activities required to design, produce, and deliver a good or service to a customer…" [4]

Creating **Value Maps** require **representing all the tasks involved in these activities,** and then isolating the value-added actions from the non- value added ones.

For the purpose of this paper, **Value Map** for a Manufacturer is defined as **a representation of value- added tasks required to design, manufacture, sell and deliver a product or service to the customer.**

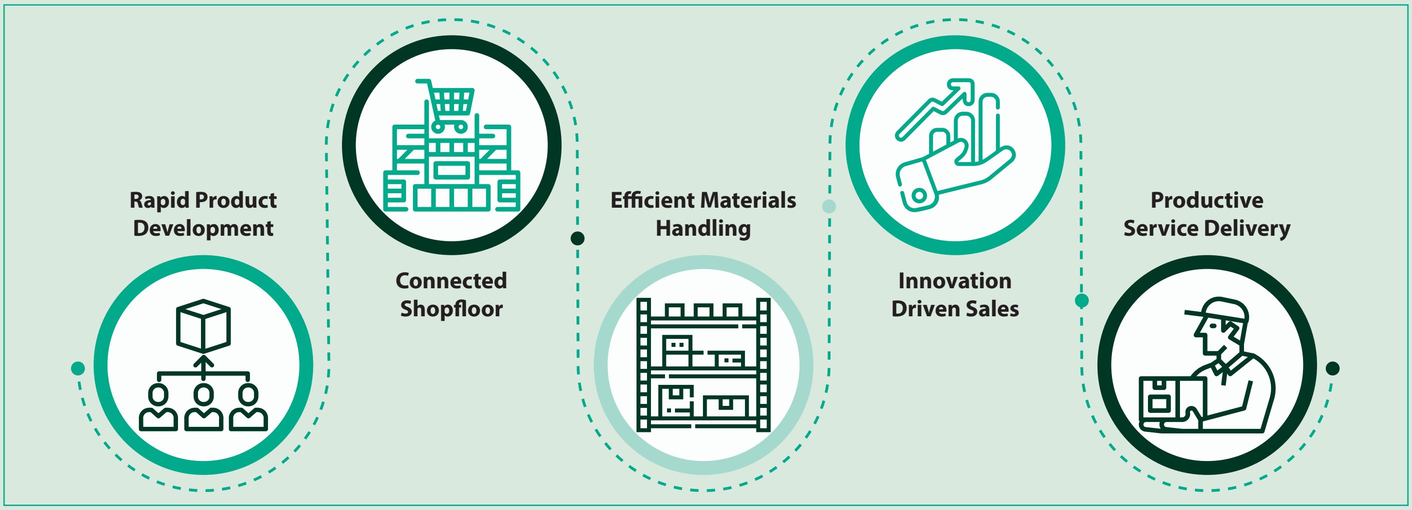


Figure 3 A Manufacturer's Value Map

IoT in the Context of Manufacturing Value Maps

New and promising technologies generate a lot of attention, publicity and noise, but in real business situations, often fail to live up to the promise. However, as the technology is better understood, its application to business contexts are thought through more carefully. The implementations happen for specific business objectives and ROIs. This helps the technology to mature and be widely adopted, albeit with realistic expectations from it. This phenomenon is captured in "Gartner Hype Cycle." Gartner Hype Cycles provide a graphic representation of the maturity and adoption of technologies and applications, and how they are potentially relevant to solving real business problems and exploiting new opportunities[5].

As with other technologies, IoT also has had its share of publicity and noise and continues to do so. However, there are also many examples where IoT use cases have been deployed by leading companies with measurable returns. Infact in the manufacturing sector, IoT is the cornerstone of Industry 4.0. However, many of the manufacturing IoT success stories we read and hear about, are pointed use cases e,g, maintenance alerts, temperature control, asset tracking etc. and not enough stories of IoT being used as a strategy for enterprise- wide value generation.

As already stated, this paper will restrict itself to identifying IoT use cases centered around **the activities that constitute the value map of a manufacturer.** The use cases will be of building block nature- meant to provide a near- term business ROI, but also to be used as steppingstone for more complex IoT use cases for the future. While the actual implementation modalities will be different, these use cases will find resonance for different manufacturing segments- white goods, industrial, HVAC, automobile and so on.

3. Value Map Functions & their Challenges

The following illustration introduces both the value map for manufacturing, as well as some key challenges around the value map functions. Understanding the key challenges that manufacturers face today around these value map functions is also important for identifying the right IoT use cases.

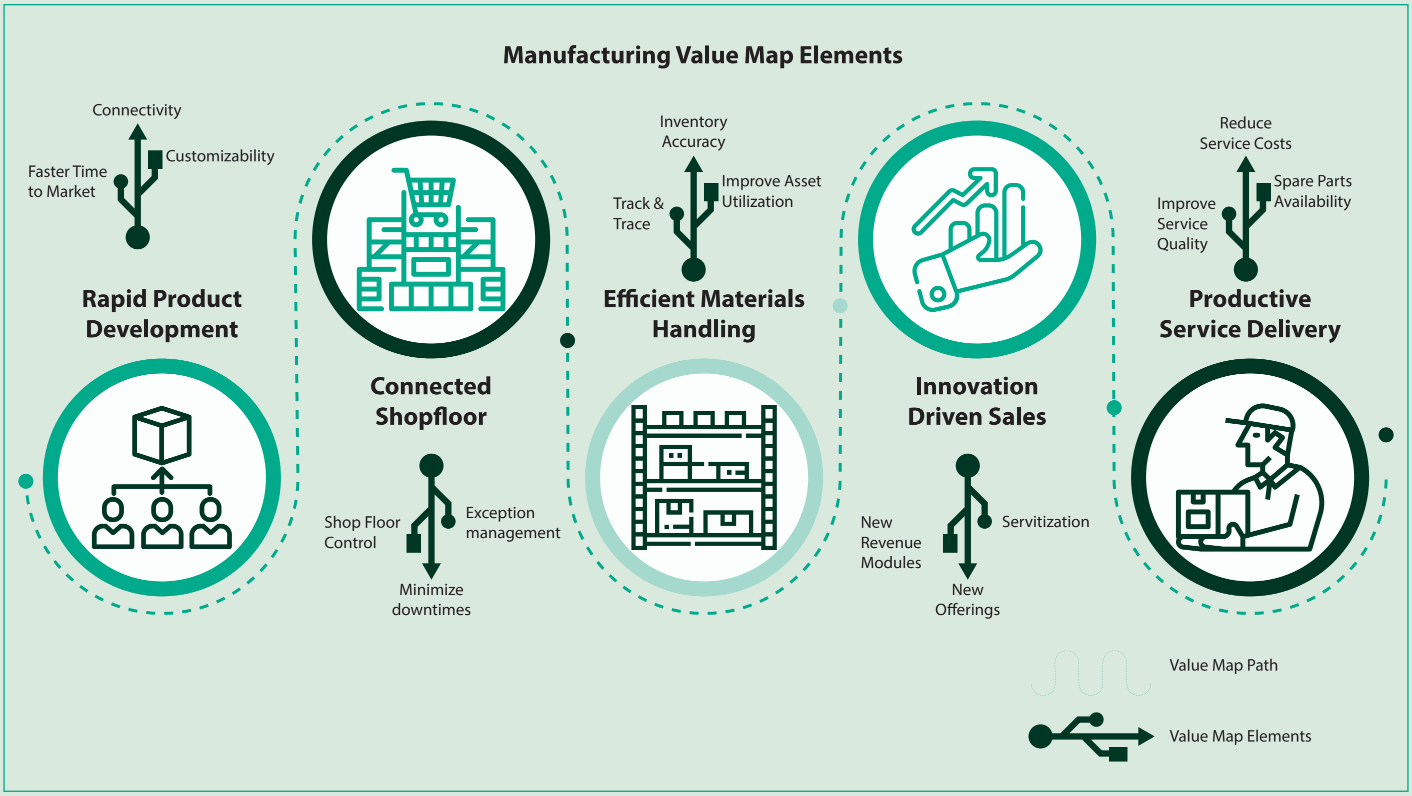


Figure 4. A Manufacturer's Value Map& Business Challenges around the Value Map

In the rest of the paper, the discussion of IoT based process transformations, are centered around addressing these challenges around the value map. But before that, we examine these challenges in more details, before moving to the IoT use cases.

Challenges in Product Development:

Competition and increasing customer power have forced the manufacturers to launch newer products and versions frequently. Newer designs and incremental version launches keep the market proliferated in the expectation of meeting the ever-changing requirements of the customers. Costly market research and focus groups to assess customers' needs delivers feedback to the Product Development group, which are then incorporated into the product design and modelled. However, time taken from researching the customer needs, to building the CAD models to prototyping and then manufacturing, often delays the product launch. Consequently, by the time the product is launched, the customer needs often get changed, making the newly launched product not tick.

Our first value map ingredient Product Development, therefore, needs quicker and better insights to customer needs and ability to faster modelling & prototyping, to cut down on the go to market time for new launches.

"You can't just ask customers what they want and then try to give that to them. By the time you get it built, they'll want something new."

Steve Jobs

Challenges in the Shopfloor- "Whats Happening On My Shopfloor?"

Most manufacturing floors today usually have some degree of automation. Such automation has in fact been around for decades in the form of CNC (Computer Numeric Control), PLC (Programmable Logic Control) machines and so on. These machines use sensors that collect operating data and pass that on to the controller units. Then there are the RTUs (Remote Terminal Units) that are attached to the machines that collect sensor information and then pass them wirelessly to SCADA (Supervisory Control And Data Acquisition) servers to analyze and send control signals back.

However, these machines work in silos, where the automation is restricted to specific work centers and processes and the data being exchanged are specific to the machine manufacturers– thus making the shop floor operate like islands of automation. The information and signals from all the machines in the floor are not connected, thus making the supervisors ask the question "What's happening on My Shop Floor?"

Our second Value Map ingredient- Shopfloor, therefore needs to connect the information that are being generated across the different work centers, operations and lines, and use them to improve product quality and reducing costly downtime.

Challenges in Material Handling- "Where is My Stuff?"

A common question in Material Handling activities is "Where is my Stuff?" Despite having an ERP and WMS, warehouses often have problems finding parts. To ensure things are at the right place, warehouses must periodically engage in Cycle Counting and Physical Inventory- which are time and effort consuming affairs.

Key to efficient warehouses are layout design that helps optimize the efforts for putaway and storage. These are also impacted by the efficiency and productivity of the warehouse assets such as forklifts and operators. Knowing where these key assets are in the warehouse at any point of time, will allow for supervisors to handle exceptions in a timely manner and optimize the throughput of the warehouse.

Thus, for Material Handling ingredient of our Value Map, inventory accuracy and tracking, and asset tracing are key imperatives.

Challenges in Sales- "How Do I Sell More?"

The perennial sales question- "How do I sell More?" is particularly relevant in the present world. In today's times, traditional barriers to entry that manufacturers enjoyed for long, are being challenged by upstarts that are bringing new technology and paradigms and changing the competitive landscape.

Such an environment requires companies to be innovative to increase their sales revenues. This requires looking at new revenue models, bringing innovative offerings as well as collaborating with other players to keep the sales register ringing. For the Sales ingredient of our Value Map, we need to look at how IoT could help sell more.

Challenges in Service Delivery:

For manufacturers of all shades service has become a differentiator. The customer's experience with an OEM continues after the sale through the service touchpoints- and today's manufacturers place a lot of focus in making those service touchpoints experience pleasant for customers, and profitable for them.

However, service supply chain has challenges different from that of the product supply chain. The service supply chain requires managing a network of field technicians, repair centers, third party service providers, and contingent workers. As the install base of products increase, the problem of stocking spare parts inventory at the right location also increases significantly. Technicians not carrying the right parts during a service visit is the single most irritant to a customer's service experience.

Maintaining large inventory of spare parts requires higher working capital and increases the parts obsolescence risk. The transportation costs in sending spare parts across warehouses along with technicians having to make multiple trips to the customer location for the same job also add to the service costs for an OEM. The Service Delivery component of our Value Map, therefore, needs smart ways to reduce the service delivery costs, while not compromising on customer service levels.

4. Introducing the IoT Value Map for Manufacturing

The following illustration adds the proposed IoT use cases to the earlier Value Map diagram.

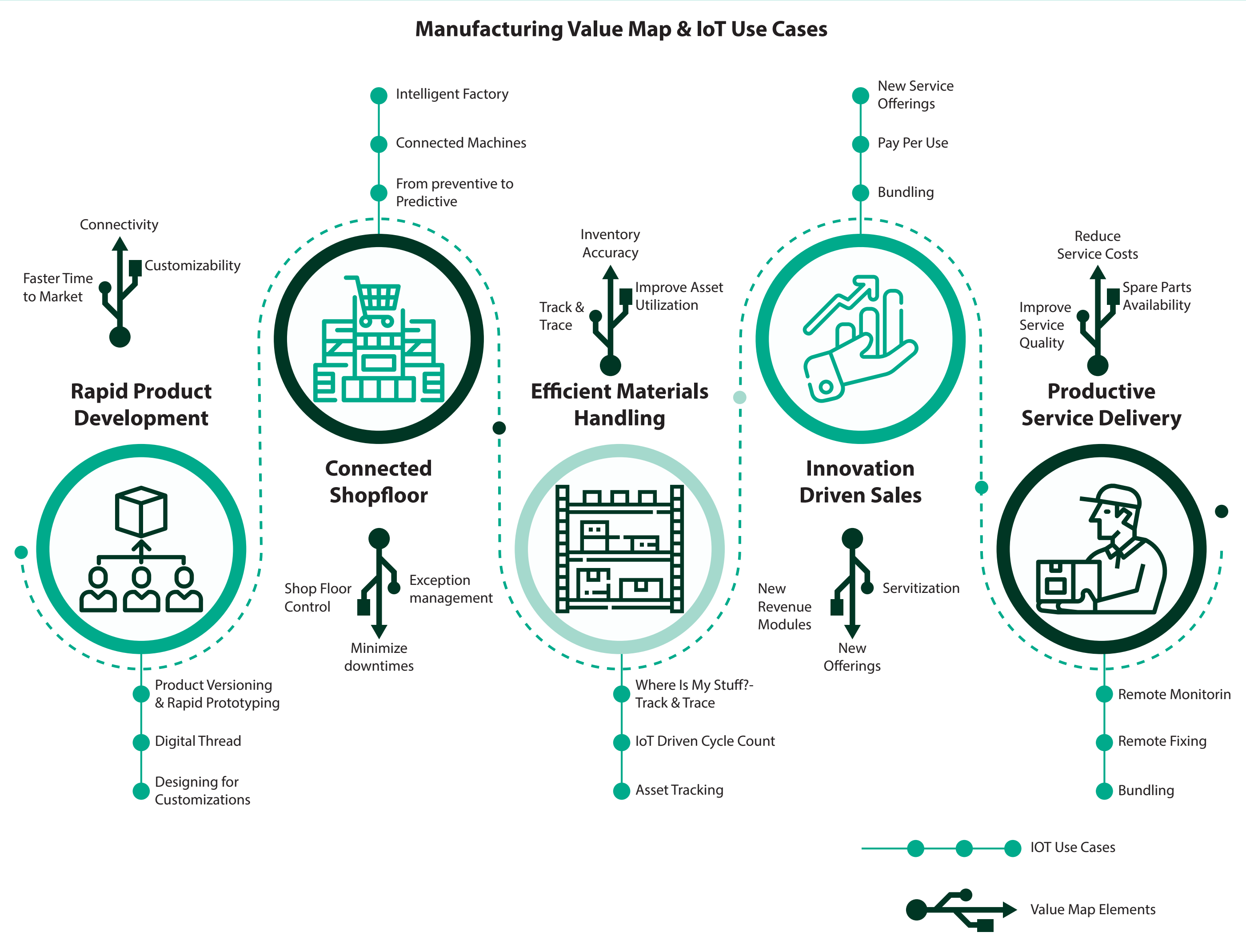


Figure 5. IoT Use Cases for Manufacturing Value Map

These use cases have been included to address the challenges listed in the previous section. The following explains each of the listed use cases in the context of the aforementioned Value Map.

I. IoT Use Cases for Product Design:

Digital Thread: Information from sensors present in a product are collected, analyzed and in some cases fed back throughout the lifecycle of the unit from design, manufacturing, sales and service- creating what is called a 'Digital Thread' for the product. The digital thread is of immense value to R&D Teams in designing right products for the market as it provides information regarding quality, defects, maintenance need and manufacturability. Additionally, the installed products provide valuable information regarding how they are being used by the customer- usage time, usage frequency, hours, connectivity to other devices etc.. Such information is of immense value to the product design team as they are able to understand how their product is being used by the customer and use that feedback to design subsequent products that enhance consumer's experience. This allows them to bypass costly market research and focus groups and instead be nimble with product launches. Incremental product versions, instead of a totally new product, to fix specific customer problems become possible by using the Digital Thread's information, thus reducing the time to market.

3D Printers for Rapid Prototyping: Use of 3d printers and additive manufacturing, allows Engineering teams to now build prototypes quickly based on the designs. This helps them assess the form, fit and manufacturability of a new design better compared to software based modelling. This also helps to discard a prototype and build a new one quickly thereby improving the time to market.

Customizability: While mass customization is an ultimate goal for manufacturers, it is quite costly to achieve. However, designing for customizability is an important tenet of product design in the new world. Sensors share various information with R&D departments regarding customer conditions and preferences such as space requirements, temperature, moisture content, air quality etc.. Such information are used to create a product design that allows for some specific customizations- achieved through configurations or nodular form and function design.

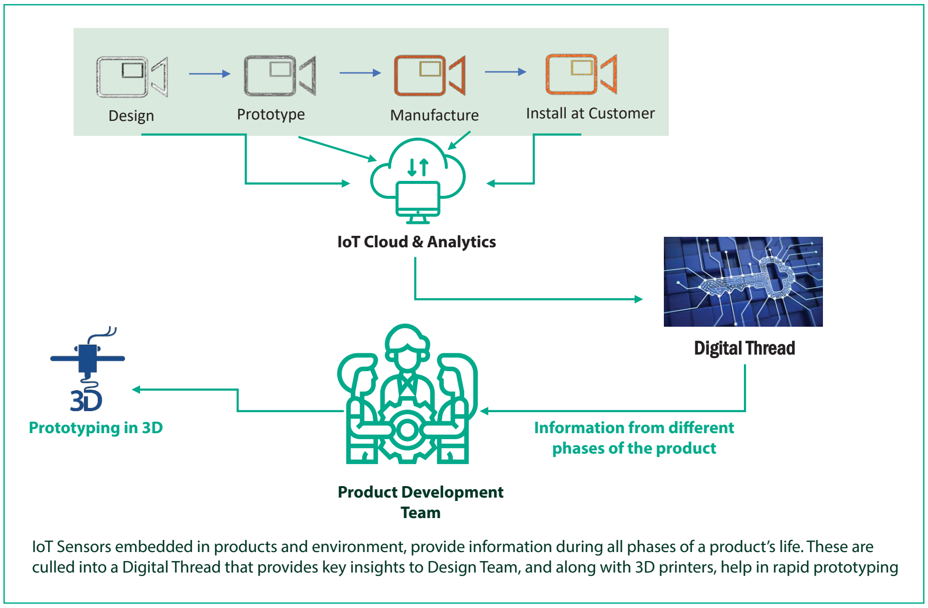


Figure 6 Device Sensor data being used for Product Design

II. IoT Use Cases for the Shop Floor:

Usage of sensors in manufacturing shop floor is not a recent phenomenon. The use of sensors to detect changes in analog signals (e.g. vibration, pressure, noise, temperature, motion etc.) and using them for controlling the behavior of machines is commonplace in manufacturing. However, the acquisition of the sensor data, the conversion of analog signals to digital voltage and the subsequent controlling actions, is often part of proprietary technology of machine manufacturers. As such, while process controls are done automatically based on data captured by sensors, such data are usually limited to specific processes and machines on the shop floor and not exchanged with other machines or processes to be put to holistic use.

Connected Shop Floor: One of the upfront values that shop floors could derive from IoT is to collect the data from the existing sensors already present in the shop floor, to a common platform and create a Real Time Connected Shop Floor Solution. This is relatively simple to achieve, and yet not present in many factories.

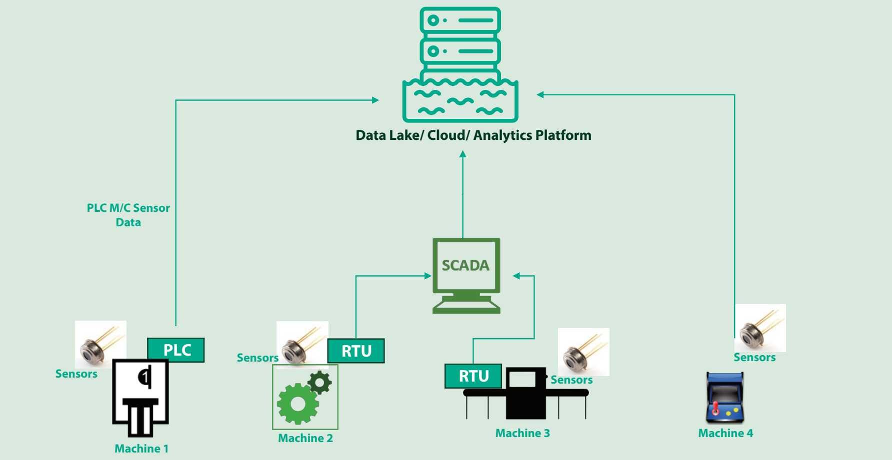
Production Supervisors will be able to monitor machines, product rates, identify potential bottlenecks in the line, move the workpiece to alternate machines in case of breakdown and other exceptions. Besides, this also makes monitoring and comparing KPIs a mouseclick effort. In short, this will help answer the questions of many factory supervisors- "Whats happening on my Shop Floor?"

Intelligent Factory: The next IoT use case, is to have Advanced Analytics have a go at the collected sensor data. Analytics engines are able to identify patterns in the outcomes of a machines, based on patterns of upstream machine data. For example, defect occurring at a downstream machine could be influenced by the workmanship of a particular operator in an upstream operation. Such insights will help the supervisors identify the cause of the defect in say operation 70, as something that happened in operation 20 and try to correct it there.

Similar analysis will be done for scrap, rework and the causes could be isolated based on patterns analysis. Machine Learning could also be used to predict, for example, a defect in a particular production line, is likely to occur in which shift next!

Both the shop floor visibility as well as the pattern detection, are use cases that will bring significant benefits to manufacturers, without having to make any changes to machinery, layout etc.. By reusing existing sensors, these use cases shift the risk of the implementation on the software rather than on the shop floor and help in creating the initial IoT success stories for the plants – preparing them for complex Industry 4.0 use cases in the future.

From Preventive to Predictive Maintenance: Perhaps the most common shop floor IoT use case, is that of downtime minimization. Downtime is usually costly, and oftentimes bring contractual penalties with them. Sensor data from machines on the shopfllor will be used for predicting the likely maintenance schedule for machines. These schedules could be integrated to the ERP or maintenance softwares, to easily trigger work orders for maintenance, dispatch the work orders to resources based on skillset as well as raise requisitions for parts needed for the maintenance jobs. This moves the plant from a preventive maintenance schedule to a predictive maintenance one.



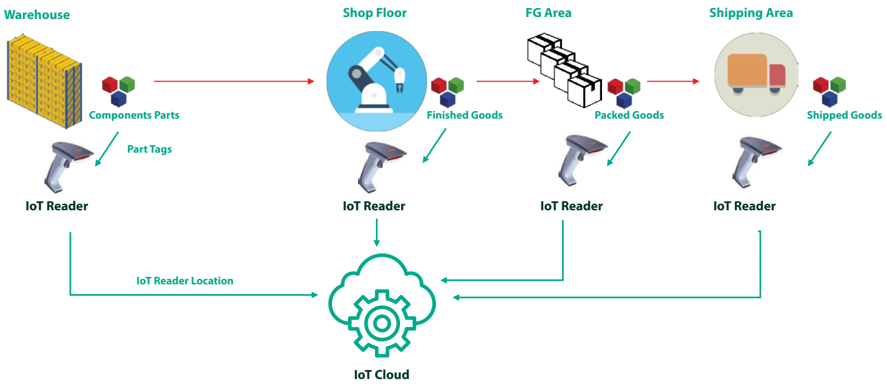
Automated Machines such as PLC Machines have sensor data that are stored within the machine. SCADA systems use Remote Terminal Units (RTUs) to get data from machine sensors in its ecosystem. Complete Shop Floor Visibility will be obtained when all the different machine data are connected and analyzed for better control, pattern detection and downtime minimization

Figure 7 Connecting the sensor data to form a holistic picture

III. IoT Use Cases for Material Handling:

Where is My Stuff?: This is a question that often gets asked around in the stores, warehouse and other floor areas. While ERPs show onhand quantity, people just cannot locate them physically on the floor. This perennial problem could be tackled quite simply by using tags and scanners. The ever-decreasing cost of RFID tags allows them to be placed on products, and as these products move through the warehouse or get stored, these tags are read by RFID readers placed at different positions in the warehouse. The data from the tags and RFID readers are transferred to the IoT network, where the latest location of the parts get recorded and displayed. This will help warehouses answer most of the questions around "where is my stuff?" for good.

Cycle Count and Physical Inventory: Critical to inventory accuracy, these processes involve physically counting items in the shelves and other areas, reporting them to the ERP or WMS systems, and then making adjustments to correct the differences. While many organizations today use barcode labels and scanners, use of RFID and IoT could transform the efficiency of these processes. This is because while barcode readers operate using 'line of sight principle', requiring count operators to move and flip a part till they find the label to scan it; RFID tags and other IoT sensors do not need line of sign to transmit data. Additionally, tags placed on containers share information about individual items within the containers, thus eliminating need to scan each item separately, saving lots of time. This allows operators to count items with higher efficiency and accuracy than present day barcodes.



Using tags on parts, the item movement details are captured in IoT sensors stationed throughout the facility e.g. Warehouse, Manufacturing, Storage, Shipping etc. and sent to the cloud along with the IoT Reader's location. These information help accurately know where a given part is at, at any point in time throughout the facility.

Figure 8 Tags on products and IoT Readers stationed across the warehouse

Asset Tracking in the warehouse: In addition to the products, other assets in the warehouse include equipments such as forklifts and human resources such as picking operators. Ability to track the movements and whereabouts of these assets in the warehouse is very important for improving warehouse efficiency and lowering costs. Simple positional Sensors placed on forklifts and wearable bands placed on operators, will allow data from both equipments and operators to be sent to the IoT cloud. Availability of such data will help identify idle time, movement of resources from an underloaded zone in the warehouse to an overloaded zone, managing exceptions quickly, dynamic task dispatching and so on.

Such data also help in ascertaining the capacity utilization, peak loads and idle times of the assets. Advanced applications could be built to track the paths of movement of the forklifts in real time and use that information for better route planning, reducing congestion in the warehouse, forklift traffic management etc,.

Track and Trace: Once outside the warehouse, the sensors placed on the item packages could continue to be used, coupled with IoT systems placed on the vehicles to deliver track and trace information on the go.

These use cases will definitely allow manufacturing companies get started with their material handling IoT initiatives and realize benefits quickly.

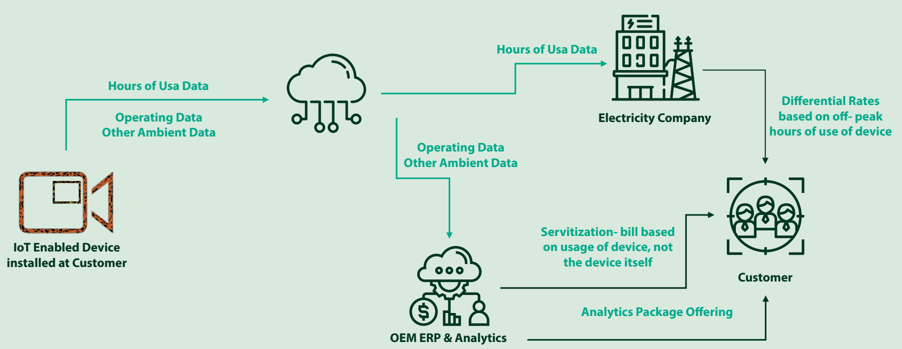
IV. IoT Use Cases for Sales:

New Service Offerings: Once a sensor is built into a product, several additional services become possible. The data from the sensors could be commercialized as an offering along with the product. For example, machine manufacturers sell the product and provide a value offering wherein they share some sensor-based data from the machines with the customer for free. However, **analytics based insights** are sold as a separate offering to the customers. So along with the product, OEMs also make use of Data and Analytics to create additional revenue stream. Caterpillar's Cat® Product Link[6] service tracks locations of equipments, among other things and shares them with the customers.

Servitization: IoT technologies built into devices, enable multiple new revenue models. Servitization is a consistent theme among different manufacturers now. A commonly cited example is that of Xerox charging for number of photocopies made instead of selling the photocopier machine. The feeding of operating and usage data by the sensors, allow OEMs to charge their customer based on usage of the product, rather than the sale of the product. This trend could become more and more pervasive sooner as more industries get the data necessary to charge for their products based on the usage.

Collaboration & Bundling: OEMs could also collaborate with other players to share their device IoT data, to build new revenue models, For example, power grids get the data for hours during which Air Conditioning has been used, and charge customers a lower rate for off- peak hours usage and a surcharge for peak hours usage.

Cross Sell & Up Sell: Data from the machines could be used to identify potential upsell and cross sell opportunities. For example, based on telemetry data collected from a vehicle or an equipment, a customized maintenance/ repair package could be sold.



IoT Devices help in innovative offerings including Servitization of the OEM's Product, Analytics Packages, Collaborative offerings with other players e.g. Utilities Companies

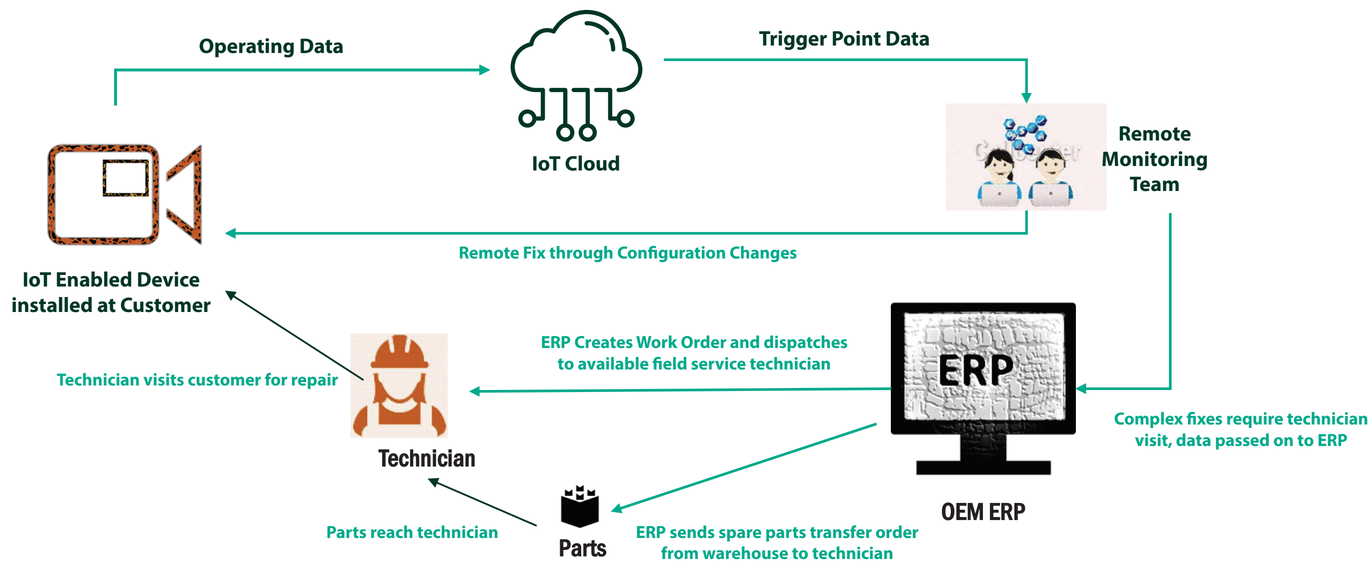
Figure 9 Sensor transmitted data make additional offerings possible

V. IoT Use Cases for Service Delivery:

For quite some time now, as product-based revenue growth has flattened in several industries, manufacturers have been looking at services and aftermarket operations as means for revenue growth. Sensors embedded products that are able to capture and send operating data back to the OEMs, have opened up avenues for both additional revenue models, as well as reducing service costs. This focus on services, repairs, extended warranty, maintenance contracts etc. has opened possibilities for many IoT based process transformations ideas. A few around the value map are discussed here.

Monitoring Remotely: Allowing OEMs to monitor the machines from a centralized data center and based on usage and analytics, schedule technicians and parts for any preventive maintenance work before a breakdown happens.

Remote Fixes: Depending on the device type, some configuration changes could also be remotely carried out to fix certain problems, thus saving a physical trip by a technician. This will help OEMs keep costs low for executing Service and Maintenance contracts.



IoT enabled Devices reduce service costs by sending operating data, which allows certain fixes to be done remotely, thereby reducing field technician visits

Figure 10 Remote Fixing reduces technician visits while analytics improve spare parts availability

Spare Parts Availability: Availability of spare parts is a major area of challenge for all aftermarket services. The interaction between OEM and non- OEM parts warehouses, third party service providers, contingent workers and large number of spare part SKUs, makes ensuring right parts availability a challenge. This leads to stockouts of spare parts at the needed place and at the needed time which prevents the service job from being carried out.

The operating and usage data coming in from the IoT sensors in the installed devices, coupled with historical information of breakdowns and repairs and install base data could predict the likelihood of service demand and parts needed at a particular area and in a given time period, thus enabling the spare parts inventory levels to be stocked appropriately.

5. Need for Building Segment Specific Value Maps

The IoT Value Maps suggested in this paper, encompass the manufacturing industry at a broad level. Most of the ingredients that have been considered as part of the manufacturer's value map in this paper, are common to different manufacturing segments such as Industrial, Automotive, Heating Ventilation and Air Conditioning (HVAC), High Tech etc.. For example, Product Innovation, Operational Excellence, Manufacturing & Logistics, Responsive Service Networks, Sales & Aftermarket, Asset Monitoring and Field Service, Spare Parts Network etc. are some of value ingredients that are common across different manufacturing segments. As such by extension, the IoT use cases proposed here, are also applicable to all these segments.

At the same time, each manufacturing segment has specific ingredients in their respective value maps that differentiate themselves from other segments. For example, Dealer Management in case of Automobile segment, managing Changing Regulations & Compliance requirements in case of HVAC, Distribution in case of High Tech etc. are value adding ingredients for respective segments. Within the Infosys Oracle practice, Industry specific value maps have been created for Industrial, High Tech, HVAC and Automotive segments, among others. These value maps could be used to identify the IoT use cases for the incremental value adding ingredients specific to each segment. The following shows the HVAC industry value map, as an example.

The intent of this paper is to prepare the IoT value maps for manufacturing industry in general and not to deal with segment specific variations. However, the HVAC industry value map is used only as an example to illustrate a case of such incremental segment specific variations.

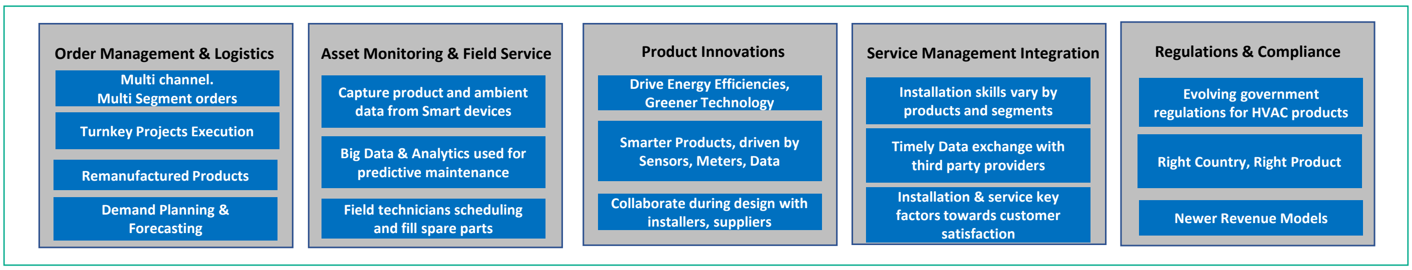


Figure 11 Example of HVAC Industry Value Map

Example of Segment Specific Use Case:

The key incremental function in HVAC value maps, is the management of constantly changing Regulation and Compliance requirements. HVAC industries are subjected to ever changing rules and regulations around energy efficiency and power consumption. IoT Sensors embedded into the HVAC device or system help reduce energy consumption significantly. Using thermal or motion sensing IoT sensors, HVAC systems could determine the number of people present in a room and adjust the temperature automatically. Similarly, sensor data from HVAC units could be analyzed for identifying comfort level temperature settings for users and corelating that with outside temperature data over a period of time, and then automatically regulate temperatures inside the room.

Similar use cases for other segment specific functions will be required to identify segment specific value maps, and IoT transformations thereof.

IoT provides business to transform their core processes and make them intelligent and adaptive- and the choice to technology platform also plays a key role in this strategy. The Infosys Live Enterprise is one such platform that helps customers do just that.

6. Conclusion

As the world limps back to normalcy and learns to live with the COVID_19 pandemic that has wreaked havoc, the world of technology is certain to undergo some changes. As the global 'pause' button is lifted, businesses will take a hard look at their forthcoming initiatives and have to make tough capital allocation choices – to spend money for achieving near term goals or invest for newer capabilities that will have RoI in the longer term. The world of technology will not be spared of this choice. Of the many technologies that is shaping our world now, the Internet of Things is arguably one of the most powerful. Unlike many others, this is a transformative technology in the true sense of the term, as this could take a process and overhaul it with new capabilities, new opportunities and newer revenues. As powerful as it might be, even the IoT space will require manufacturers to clearly justify the business benefits before any IoT spend is authorized.

It is in this decision process, that the use cases illustrated in this paper is expected to help the manufacturers. This paper has adopted a Value Path approach, identified challenges around the value path, and then recommended specific IoT use cases to alleviate those challenges. The IoT Value Map is expected to be of help to manufacturers of all hues- industrial, white goods, automotive, HVAC and high tech. The details will vary for each manufacturer, but the approach and the suggested use cases will serve them to achieve the IoT returns they want- both for the near term as well as in being the building blocks for long term IoT transformations.

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