Volume #9: Modernization of Things Manifestations

Our previous Strategy Report discussed the manifestations arising from *Low Domestic Energy Prices* and how those manifestations are impacting 3RC's approach when searching for and analyzing investment opportunities. This report examines the next Factor of Influence, *Modernization of Things*, and dives into the manifestations that are most relevant for 3RC and our investors.

The table below serves as an outline of the key manifestations that we will investigate throughout the following pages of this report. We are tracking several manifestations that will continue to shape 3RC's thematic lens and will lead our search to uncover the most compelling investment opportunities for our investors.

As shown in the table below, three major factual drivers that 3RC is in position to take advantage of related to the Modernization of Things are the increasing necessity for technological innovation to fuel growth, advancements in the Internet of Things (IoT) and Artificial Intelligence (AI), and the modernization of infrastructure within the United States.

Before these factual drivers are examined in-depth, it is important to clarify that 3RC will not invest in software or technology development companies directly. Instead, 3RC will focus on the companies that are positioned to implement this technology to create actionable insights and increase the value-add of their services. While this report does investigate many factors like IoT and AI, 3RC is aware of the massive technology risks associated with many venture-style investments that make up those spaces. What this report has found is that technology is permeating segments within our investment thesis and that it is important to acknowledge and accept these impacts. By doing so, 3RC will be able to find opportunities without significant technology risks but are also prepared for the new, tech-enabled world.

Factor of Influence	Factual Drivers	Manifestations
Modernization of Things	Increasing necessity for technological innovation to fuel growth	• Technology fuels overall productivity growth, which is important for companies with stagnating growth rates • Companies are using embedded technology within existing systems to adapt to technological advancements
	Advancements in the Internet of Things (IoT) and Artificial Intelligence (AI)	• Predictive maintenance, or solving problems with machinery before they arise, is enabled through constant IoT monitoring • Improvements in the industrial base and machinery to increase the use of automation • Companies that provide specialty maintenance services and installation will become more prevalent
	Modernization of infrastructure within the United States	• The current administration has already outlined an infrastructure spending plan • An increased amount of maintenance spending is necessary to manage infrastructure • Technology has been applied to help simplify the maintenance planning and analysis process

Technology's Importance

Technology has a long history of increasing the efficiency of organizations and improving the lives of everyday Americans. In a study by researchers at Harvard and Johns Hopkins, innovation accounts for the

majority of overall productivity growth.   Many variables that fuel economic growth in the United States have already reached a limit, including a stagnating growth rate of wages and near-full employment. Technology growth, leading to productivity growth, is the key to unlock future growth potential.

For companies that face stagnating growth, one solution is to turn to technology to provide revenue enhancement and cost cutting opportunities with the goal of increasing overall profitability. Retailers, for example, have built mobile applications to escalate sales and have adopted cloud computing to eliminate the high costs of in-house servers.   This generates tangential investment opportunities, which is what 3RC is looking for. In this case, the companies that build and service the cloud storage facilities, provide tech-enabled logistics solutions, and produce packaging for product shipping are of particular interest. Incorporation of new technology across industries will be potential investments for 3RC and will empower 3RC to capture the rapid growth rates of these innovative industries.

Embedded Technology
Embedded technology, or "specialized hardware and software that is wholly incorporated as part of a larger system or machine,"[1] has been helping companies modernize and stay relevant to tech-savvy users. The technology, along with many of the other trends that will be further discussed in this report, is applicable to end markets ranging from entertainment to banking.

One unique niche that illustrates the impacts and implementations of embedded technology is the point-of-sale (POS) systems used in retail stores and restaurants. The original POS systems were cash registers and were used to make change for customers. This quickly evolved to incorporate technology over time to record which products were sold for data analytics purposes, and also sped up the process by allowing certain buttons to be pressed for different items and prices. Again, this illustrates the ripple effect caused by technology developments, as advanced POS systems have been developed in response to new payment channels such as credit cards and Apple Pay.

Embedded technology extends beyond the POS system and into markets that are more applicable for 3RC. Different types of technologies, providing increased durability and ease-of-use capabilities can be implemented to create different lines of specialized products.

The Internet of Things (IoT) in the Industrial & Manufacturing Industries
Many common applications of the Internet of Things (IoT) are consumer-facing, which include smart door locks and other connected home devices, but many functions also exist for the valuable IoT technology within other industries. 3RC will have the opportunity to explore investments in companies that develop, implement, and service IoT components within a few 3RC-oriented verticals.

Manufacturing is one industry in particular that has already seen the impacts of advancements in IoT technology. A report from McKinsey & Co. discussed how the IoT "has already set in motion the idea of a fourth industrial revolution—a new wave of technological changes that will decentralize production control and trigger a paradigm shift in manufacturing."[2] Building maintenance services alone account for a market size of $176.5 billion[3].

Predictive maintenance, or constantly tracking equipment to monitor when repair or replacement is necessary, is the solution to reduce overall maintenance, repair, and downtime costs for manufacturing companies. Within a complex manufacturing system, traditional maintenance models are outdated as issues could arise at several different points in the process itself. The data to solve these problems is easily available and captured, but "72 percent of manufacturing industry's data is unused due to the complexities involved with variables, such as pressures, temperature and time."[4] IoT solutions can help make this data worthwhile by using predictive maintenance and connecting to all components involved.

Currently, the industrial IoT market is valued at $11 trillion and has the potential to stop many maintenance problems before they occur and could help save $630 billion for companies over the next 15 years.[5] In addition, predictive maintenance could help reduce the $20 billion in total unscheduled downtime, which accounts for 5% of output value.[6] The predictive maintenance market alone is expected to grow to $4.9 billion in 2021 from $1.4 billion in 2016, a 24.8% CAGR.[7]

Platforms that centralize the massive amount of data that is collected by IoT will be able to capitalize on the predictive maintenance trend by creating actionability for manufacturing plant managers. These platforms can also expand into the supply chain and performance analytics markets as well, further expanding their total addressable market sizes.

One area of particular interest to 3RC is the predictive maintenance trend in manufacturing maintenance service companies that utilize the IoT to accurately implement services and reduce plant down time. These companies will be able to provide solutions to their customers at a far lower price by partnering with IoT companies and understanding when problems will occur. Over time, as more data and analytics are collected from different plants, companies will be able to predict problems even more accurately. This will build defensibility against potential competitors, as each manufacturing plant faces their own set of unique problems and past data could be applied to quickly implement solutions.   As predictive technologies continue to advance, other tangential service industries could become attractive to 3RC such as inventory and logistics management.

Improvement of the Industrial Base and Increased Demand for Maintenance Services
The first robot used in an industrial setting was developed in 1961 and was implemented on a General Motors assembly line.[8] In the late 1960's and throughout the 1970's, robots spread through factories around the globe but could only "replace humans for the heavy, dangerous, and monotonous tasks."[9] Since then, advancements in mechanical engineering and the implementation of artificial intelligence (AI) have enabled robots to take charge of more tactile tasks that were previously reserved for more skilled human workers.

The applications of AI in manufacturing were examined in a 1986 article written by Mark Fox, a researcher from Carnegie Mellon University. Dr. Fox claimed that "systems that integrate more knowledge about the factory floor and, hence, make better decisions will be created."[10] This concept has evolved and is now being used in machine vision applications to enhance the capabilities of robotic machinery in factories.

Machine vision is "the use of devices for optical non-contact sensing to automatically receive and interpret an image of a real scene in order to obtain information and/or control machines or processes."[11] The primary applications of the technology have already been utilized in the automotive, logistics, and packaging industries, though the technology is also valuable in manufacturing processes.[12]

The incorporation of machine vision into traditional manufacturing robots allows the machines to handle a wider variation of products with accuracy improving over time due to the implementation of machine learning. Due to this, robots are now being used at the inspection stage to identify defective products, a task that would be unimaginable just a few years ago. These capabilities prompted Apple to invest $10.5 billion on smart robots in 2013. In fact, overall demand in this sector has been increasing rapidly, with North American sales in the first half of 2017 reaching $1.03 billion for 19,331 robot units, a 33% growth in units compared to 2016.[13] This technology is currently limited by the number of tasks that a single machine can do, but companies like Cognex and Google are developing solutions to allow machines to allow robots to switch to different applications.

While the technology being developed is fascinating, 3RC will focus on the tangential companies that will

benefit from these advancements. Manufacturers will be unprepared to handle the constant maintenance that is required of advanced machines, and new service-based companies will arise that will provide consistent maintenance and repair on these valuable machines. As companies realize this need to modernize, service companies that implement these solutions will be in demand. Infrastructure will need to be updated and, in certain cases, built to account for rapid technological changes. One example is colocation data centers, which are data center facilities where businesses can rent space for a wide range of computer hardware.[14] These centers reduce costs for each company involved, as many small and medium-sized businesses want to avoid the initial capital expenditures of building private data centers. This sector is expected to experience a 13.4% annual growth rate through 2021 to $25.4 billion from $13.8 billion in 2016.[15]

The growth of the colocation data center market has also lead to growth for companies that maintain and service the facilities. Many companies start by working on the initial construction planning and analysis for these facilities and transition to maintenance and service following completion of the projects. As a result, these companies generate a large amount of recurring revenue which reduces the overall risk of the business by increasing the predictability of sales.

Outside of recurring maintenance and service revenue, these companies can also benefit from additional technological improvements that necessitate infrastructure updates. Customers will rely on these service-oriented businesses to implement the technology in a way that fits their needs, leading to further revenue in the future. Larger facilities services companies are focused on adding technology-enabled services to their suite of offerings as well, and companies that provide niche maintenance and services are valuable targets for strategic acquirers.

For these reasons, service-based businesses that are highly specialized, recurring, and focus on construction, maintenance, and remodeling of technology-enabled facilities are attractive to 3RC. The technology risk is reduced as these companies are not developing the products by themselves but are still able to capture industry growth. By serving as the stakeholder that implements new technology solutions to those that need it, specialty contractors provide a strong value-add service for facilities. 3RC will focus their search within the diversified specialty contractor space, which includes companies with less of an emphasis on new construction projects and more of a focus on remodeling current systems.

Modernization of Infrastructure
Despite the discussion surrounding technological advancements that are impacting 3RC's verticals, the concept of the Modernization of Things can also be extended to maintaining and updating infrastructure as discussed in the previous report. The United States has fallen behind on updating their infrastructure which has led to poor roads, bridges, public transportation, and water and energy systems across the nation.

For 2017, the American Society of Civil Engineers gave the United States a grade of D+ for overall infrastructure and noted that improving this grade would require $4.6 trillion in spending.[16] Most of this deficit has been caused by a consistent lack of requisite maintenance spending needed to prevent deterioration over time. This is illustrated in road spending, where, between 2009 and 2011, states invested $20.4 billion annually to expand road coverage by 1% but only spent 45% as much on maintenance for the remaining 99% of roads.[17] It is clear that action must be taken to ensure that this deficit does not grow even larger.

The current administration has proposed the concept of a $1 trillion increase in infrastructure spending to bridge this gap, which is only 22% of the $4.6 trillion needed.[18] This will necessitate significant private capital investment to fill the space between these two figures. While implementation of a defined plan is

uncertain, the importance of infrastructure maintenance spending will only grow as a priority for state and national governments. Construction projects require maintenance after they are finished, as "each new, large infrastructure project creates significant demand for equipment and services not only for construction-related purposes, but also for annual, recurring maintenance, repairs, and upgrades."[19] Companies that can provide maintenance services to prevent deterioration following the initial construction of new infrastructure will grow as a result.

Recent studies, including one performed at the University of Illinois at Chicago, found that "state and local governments have overinvested in [new] construction while underinvesting in maintenance, repair, and general upkeep."[20] States will likely redirect a portion of initial construction spending to maintenance in order to prevent further capital expenditures once projects depreciate. The value of this spending has also been backed by research, and modern analysis has found that "maintenance can have a significant and positive effect on productivity and economic growth."[21] Companies that only provide maintenance for new construction projects will see an uptick in demand for maintenance of current infrastructure following local spending changes.

Predictive maintenance has also changed the dynamics of the United States' infrastructure maintenance market. Technological improvements, specifically "sensing, deterioration forecasting, and asset management" have combined to reduce the costs of maintenance in the past few years.[22] By applying advanced, technology-enabled monitoring, maintenance schedules will become more foreseeable which will allow governments to construct their maintenance budgets with reasonable foresight. Several technology companies have developed the monitoring technology and have started to implement it nationwide.[23]

One application of predictive maintenance technology is optical vibration sensing which uses video to gather data on certain types of critical public infrastructure. This technology was first applied to bridges, which previously required teams of analysts on scaffolding to manually examine and capture data on deterioration. The optical vibration sensing "precisely measures surface vibrations on the structure being analyzed and then estimates the degree of internal deterioration based on the characteristics of those vibrations."[24] By facilitating data capture and analyzing that data effectively, governments will be more aware of maintenance requirements and the state of their infrastructure.

As maintenance expenditure increases as a whole, companies that create products that are used in infrastructure construction will also be utilized in the maintenance of these projects. For example, as road maintenance expenditure is expanded, more asphalt, safety equipment, and machines that build those roads will be needed. 3RC will focus on companies that are prepared to utilize new maintenance technology developments and also those that provide the materials needed for maintenance itself. These companies will be able to provide a greater level of efficiency in their maintenance planning and analysis which will allow them to charge less to their customers and manage an increased number of maintenance projects. Additionally, these companies will be shielded from a large amount of technology development risk as they will be implementing the solutions that have been built by software and application development companies.

As the Modernization of Things continues to manifest itself through additional technological advancements in different industries, 3RC will focus on areas where they are able to use their experience and strategic advantages to capture returns for investors. The importance of technology in national growth cannot be understated, and companies have already started embedding technology in products to increase their own productivity. Advancements like IoT and AI are providing companies with improved maintenance processes and are reducing capital expenditures. Finally, companies that maintain and service manufacturing and critical infrastructure systems are now armed with advanced monitoring

technology that will set them apart from their competitors. As 3RC continues their Strategy Report series, understanding the manifestations of the Modernization of Things that have been discussed in this report will be crucial to our investment strategy moving forward.

SOURCES:

[1] Army Knowledge Management and Information Technology
[2] McKinsey & Co.
[3] Freedonia
[4] Gartner
[5] Manufacturing Business Technology
[6] Stratus
[7] Markets and Markets
[8] HistoryofInformation
[9] RobotWorx
[10] Carnegie Mellon University
[11] Society of Manufacturing Engineers
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[13] Association for Advancing Automation
[14] TechTarget
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[16] American Society of Civil Engineers
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[18] New York Times
[19] Harris Williams & Co.
[20] Urban Institute
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[22] World Conference on Transport Research
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[24] NEC