THE NEW LANDSCAPE IN AMERICAN MANUFACTURING
WHAT IT TAKES TO SUCCEED TODAY

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1| The landscape of American manufacturing has changed. Manufacturing has been a key ingredient in America’s success as a nation — an engine of economic growth, innovation and upward mobility for millions. However, the requirements to stay competitive in a globalized, digitized economy are very different from the pressures that existed only a generation ago. This study is about the steps that U.S. manufacturers are taking to stay ahead, using the experience of 90-year-old aircraft-engine manufacturer Pratt & Whitney to illustrate how the world has changed and how an industry-leading company is responding.

2| Manufacturing is crucial to American power and prosperity. Manufacturing contributes $2 trillion to the economy each year, and generates 60% of all U.S. exports. It also accounts for three-quarters of private-sector R&D. A typical manufacturing worker in the U.S. earns $78,000 annually in pay and benefits, compared to an average of $63,000 for industries without a manufacturing focus. Aerospace companies like Pratt & Whitney are among the most successful U.S. exporters. Pratt, for example, contributes to a favorable trade balance with roughly 90% of manufacturing costs expended in the U.S. and more than 80% of sales overseas.

3| Global forces have reshaped the requirements of success. American manufacturers once were protected by the highest tariffs in the world, but today they must compete in a globalized economy. Roughly 95% of all consumers live outside the U.S. The information revolution — digitization and the internet — has enabled American companies to compete successfully, but that first requires a transformation in how companies operate. Emphasis on core competencies and lean manufacturing has been crucial to keeping U.S. enterprises on the cutting edge.

4| The new model of a successful enterprise is different from what came before. Major manufacturers no longer organize themselves as vertically-integrated enterprises in which every process and part contributing to a finished product is generated internally. Instead, they focus on core competencies such as design and system integration in which their skills are unsurpassed, while developing strong relationships with a rigorously-managed supply chain. For instance, Pratt & Whitney has more than 450 suppliers who contribute to its success.

5| Modern manufacturers depend on a responsive, resilient supply chain. Pratt & Whitney produced well over 50% of its parts internally during the company’s last major production ramp-up in the 1970s and 80s. That number is now roughly 20% because the company has shifted to a focus on lean manufacturing while partnering with suppliers to help address issues related to delivery, quality and cost. In many cases, small and medium-size suppliers are more efficient at manufacturing parts.

6| Lean manufacturers like Pratt & Whitney are investing in their suppliers. Pratt & Whitney has forged long-term agreements with key product suppliers who will provide critical components and parts to assemble engines for customers around the globe. The company is investing extensive technology and training resources in these relationships as it sends billions of dollars worth of work through its supply chain.
INTRODUCTION: THE LANDSCAPE OF AMERICAN MANUFACTURING HAS CHANGED

Manufacturing has been a key ingredient in America’s success as a nation since the early days of the Republic. It has been an engine of economic growth, a hub of innovation, and a source of upward social mobility for millions. Without a robust manufacturing sector, the United States could not have won wars that threatened its survival, nor could it have sustained prosperity in peacetime. It also could not have afforded to import goods from around the world, for lack of exports that would cover the cost. So sustaining America’s status as a global leader in manufacturing is vital to the nation’s future. This study is about how American manufacturing can continue to compete successfully in a rapidly changing global economy.

Manufacturing, briefly stated, is the use of labor, capital and machines to transform raw material into useful products. The term derives from the Latin words manus, or hand, and facere, meaning to make. From the dawn of history until the years immediately preceding the Declaration of Independence, that is what manufacturing meant — to make by hand. The Industrial Revolution transformed that process by substituting machinery and various forms of energy — steam, gas, electric — for human labor. The transformation has continued in recent times with the advent of the Information Revolution.

With each step in this evolution, the requirements of success changed. Manufacturing processes that were highly successful during the steam era became obsolete in the age of electricity. Manufacturers who failed to keep up went out of business. For instance, in 1911 the Boston Chamber of Commerce published a guide to the New England economy observing, “in textiles, shoes, paper, machinery, tools of precision, cutlery, jewelry, bookmaking, and many other lines, we have kept the lead.” A century later, most of those industries have disappeared — at least in New England.

The main goal of this study is to identify the practices that will allow other industries to avoid a similar fate, by staying current with the demands of a dynamic marketplace. The lessons here are drawn largely from the experience of Pratt & Whitney, the Connecticut-based unit of United Technologies Corporation, which is a world leader in the design, manufacture and servicing of aircraft engines and auxiliary power units. Pratt & Whitney recently celebrated its 90th anniversary and offers a full range of engines for general aviation, military and large commercial aircraft. The company is in the midst of a historic ramp-up because of its cutting-edge products: the PurePower engine family, with patented geared turbofan technology for next-generation passenger aircraft, and the F135 engine for the F-35 fighter.

Unlike many other New England manufacturing enterprises, Pratt has remained competitive in a high-cost region by continuously adjusting its business model and operating culture. As the company approaches its centennial in 2025, it is experiencing a surge in demand for its commercial and military engines that prove complex manufacturing still has a future in America.

The study begins by explaining why a vibrant manufacturing sector is crucial to America’s power and prosperity, and then turns to the economic, technological and geopolitical trends that have reshaped manufacturing in recent years. It describes how forward-thinking companies such as Pratt & Whitney, responding to those trends, have developed a new business model that enables them to remain competitive at the cutting edge of technology. The study argues that the comprehensive manufacturing strategy Pratt & Whitney has in place is not simply a matter of adding tooling to increase production (which is expected to double by 2020). Instead, the company has taken a longer view of its competitive situation and is transforming its manufacturing and supply chain so that it is in a position to compete globally for another 90 years.
The study explains how Pratt is focused on being cost competitive when seeking suppliers. It is not always about the lowest-cost suppliers, but about finding a supplier that can deliver perfect-quality products at competitive cost. Having a robust supply base allows the company to maintain focus on producing the more advanced, proprietary technologies internally while outsourcing items that its partners are experts in manufacturing. Pratt has invested in its own internal manufacturing capabilities and core competencies while signing long-term agreements with suppliers in dozens of countries to deliver high-quality parts and components to meet customer demands.

For Pratt & Whitney, keeping work in the United States is a focus area because of the compliance and regulation practices needed to protect the company’s intellectual property, but also because of the infrastructure and quality of the products. That said, suppliers in the U.S. and other countries have to earn their role in a resurgent aerospace sector by demonstrating that they can deliver perfect quality at the right price.

After reviewing key features of the new business model, the study focuses on how a well-managed supply chain and global network have become central to the operation of modern manufacturing enterprises. The study concludes with some thoughts about where American manufacturing may be headed in the future. In sum, the study provides a concise overview of the manufacturing “ecosystem” supporting successful enterprises in the 21st Century.
The manufacture of advanced technological systems such as Pratt & Whitney PurePower geared turbofan engines and the F135 engine for the F-35 fighter is a complex business involving hundreds of steps. The product life-cycle of an engine spans many years, stretching from initial design to development, testing, production and in-service support. Some manufacturers, such as Pratt, generate most of their revenues from post-production support of fielded systems. But to do so successfully requires building affordability, reliability and sustainability into the product from the earliest stages. Only a handful of engine companies around the world have proven capable of doing that, and Pratt & Whitney is one of them.

However, Pratt’s success isn’t just about one company. It is about hundreds of suppliers operating within a stable framework of standards and practices that make the creation of cutting-edge technology possible. Because of the criticality of suppliers, Pratt & Whitney is investing in and working closely with them to ensure they can meet quality, cost and schedule commitments. Pratt & Whitney has awarded approximately $21 billion in long-term agreements to its suppliers, enabling them in turn to invest in capital equipment and hire new employees.

More broadly, Pratt & Whitney’s success — and its effective business model for meeting an expected boom in production — is about doing business in an economic and legal system that encourages the intricate choreography supporting innovation. There has been debate about whether America is sustaining the innovation “ecosystem” required to remain in the top ranks of global manufacturers. On the one hand, the U.S. has lost five million manufacturing jobs since the most recent recession began, and its non-petroleum trade deficit in goods during 2014 was the highest ever recorded. On the other hand, a 2014 report by the Boston Consulting Group ranked the U.S. as the second most competitive manufacturing location among the 25 biggest exporters of manufactured goods.

In terms of its economic role, manufacturing contributes over $2 trillion to U.S. economic output each year, representing about 12% of gross domestic product. That is a considerable decline from the peak contribution to GDP of 28% in the 1950s, but may reflect the relatively greater efficiency of manufacturing over services (services of all kinds now account for 80% of GDP). About 12 million Americans are directly employed in manufacturing, representing 9% of the workforce; economists estimate that an additional 17 million jobs are indirectly sustained by manufacturing activity, meaning that one in five jobs across the nation are tied to the sector.

According to the National Association of Manufacturers, the typical manufacturing worker in the U.S. earns about $78,000 annually in pay and benefits, compared with an average of $63,000 for industries without a manufacturing focus. Manufacturing has been especially beneficial to workers without college degrees, who on average make 11% more in manufacturing than in other parts of the economy. However, manufacturing also employs a disproportionate share of engineers and scientists, accounting for three-quarters of all private-sector research and development in the United States. Although the U.S. trade balance in manufactured goods has deteriorated steadily since China joined the World Trade Organization in 2001, manufacturing still accounts for about 60% of all U.S. exports.

So there is little question that manufacturing remains a core feature of U.S. power and prosperity. Products manufactured in the U.S. still define the state of the art in fields as varied as agriculture, aerospace, energy, information technology and medicine. As a percent of GDP, though, manufacturing exports from the U.S. rank
relatively low compared with the contribution made to local economies by manufacturers in China, Germany, Japan, South Korea and other major trading nations. After holding steady for three decades, employment in the U.S. manufacturing sector declined rapidly during the first decade of the new century, and many observers believe the job losses are permanent. The larger question is whether America can remain a world-class manufacturer in the face of steadily rising competition from abroad.

An early assembly line at Pratt & Whitney illustrates the centrality of skilled labor to engine manufacture. Pratt & Whitney invests heavily in training the workers who populate its assembly facilities and the supply chain supporting engine production.
GLOBAL FORCES HAVE RESHAPED THE REQUIREMENTS OF SUCCESS

Some of the traditional metrics for measuring U.S. manufacturing performance are no longer useful due to changes in the global economy. For instance, high levels of employment in manufacturing may reflect inefficiency, whereas a declining share of GDP may reflect greater efficiency relative to other sectors of the economy. In order to succeed in manufacturing today, U.S. companies must deal with a host of economic, geopolitical and technological forces that have transformed the competitive landscape.

One such force is economic globalization, the removal of barriers to sourcing and selling across national borders. That trend commenced during the early postwar period with efforts to liberalize trade through the reduction of tariffs and other taxes on international transactions. From the Civil War until the Great Depression, America maintained some of the highest tariffs in the world; the duties on imports were so imposing that during the 19th Century, they typically provided most of the federal government’s revenues. Once the tariffs were dismantled -- they only average about 1% on all imports today — American manufacturers lost much of their protection against foreign competitors.

A further factor contributing to globalization was the end of the Cold War in the early 1990s, which permitted the integration of countries like China and Russia into the international trading system. After it joined the World Trade Organization in 2001, China followed Japan, South Korea and other Asian nations in pursuing economic development through greatly increased export of manufactured goods. The scale of Chinese exports posed a challenge to American manufacturers, but as the country’s economy opened up it also provided U.S. companies with unique opportunities for sourcing labor-intensive production and selling into the world’s largest market.

As the global economy was rapidly integrating, a different kind of revolution was unfolding in places like Silicon Valley — a digital revolution. Organized around the connectivity afforded by the internet, this second revolution has transformed every facet of commerce and culture in less than a generation. For manufacturers, it has fundamentally altered how they go about designing, developing, producing and supporting their products. Many tasks once performed by skilled workers are now accomplished through automation, while at the same time millions of new kinds of skilled jobs have been created that serve requirements not imagined in earlier days of manufacturing. For example, much of the job growth in the field today results from the application of digital technology in areas such as 3-D printing and just-in-time logistics.

Not surprisingly, the twin forces of globalization and digitization have produced a revolution in management philosophy at manufacturing enterprises. One important change in thinking concerns what have come to be called “core competencies.” The core-competencies movement rejects the traditional model of vertically-integrated enterprises in which every process and part contributing to a finished product is generated by the same company with varying degrees of efficiency. Instead, highly competitive companies specialize in those aspects of development and production where their performance is unsurpassed, while offloading other necessary functions to a rigorously-

managed supply chain. The decision on whether to outsource or insource is made mainly on the basis of where functions can be performed most efficiently, with an eye to keeping the enterprise as competitive as possible.

Lean manufacturing is a second management innovation that has transformed the production of goods. Started in Japan as a systematic approach to the elimination of waste, it has evolved into a strategy for continuous process improvement that emphasizes perfect first-time quality, smooth production flows, just-in-time delivery and workforce empowerment. A key measure of efficiency in lean manufacturing systems is the pace of turnover in parts inventories, which indicates whether parts on hand are being utilized at a high rate (low turnover means capital is tied up in inefficient practices). Lean manufacturing complements a focus on core competencies, and is especially relevant to companies with complex production processes such as Pratt & Whitney.

Automation of some manufacturing processes has enabled Pratt & Whitney to remain competitive in a rapidly changing marketplace. However, there are many steps in an engine’s life cycle — from design to development to assembly to maintenance — that could not be accomplished without highly trained, disciplined workers.
THE NEW MODEL OF A SUCCESSFUL ENTERPRISE IS DIFFERENT FROM WHAT CAME BEFORE

Over the last 300 years, American manufacturing has transitioned from handcrafting of customized items to the mass production of assembly lines to flexible manufacturing processes in which computers and robots replace most manual labor. This evolution has been driven in equal parts by the emergence of new technologies and the need to stay ahead of competitors. With 95% of potential consumers living outside the United States, the opportunities for increased production and profits in a globalized economy are huge. But taking advantage of those opportunities requires U.S. manufacturers to focus on areas where they have a realistic chance of remaining competitive.

For manufacturers of complex equipment such as Pratt & Whitney, that has meant shifting to technology-intensive and knowledge-intensive processes while collaborating with suppliers for many parts. While this shift to the supply base has meant that the number of machinists employed directly by the company in its home state of Connecticut has decreased, some of those jobs now reside in smaller manufacturing companies working on Pratt & Whitney products. Many of the tasks involving skilled hand labor can now be accomplished with computer-aided manufacturing, robotics and related technologies. These innovations enable the precise machining of complex parts at much lower cost and with better quality. Other advanced tasks are being performed by small and medium-size suppliers, mainly in the U.S., who were able to produce non-proprietary parts more efficiently.

What Pratt & Whitney has retained in-house are the innovative design and engineering functions at the front end of the production process, plus the final assembly, integration and testing functions at the back end. The company also operates an extensive post-production support business for engines, since competitive factors in the aircraft-engine market dictate that new engines be sold at low prices, with most revenues and returns generated from sustainment over service lives spanning several decades.

At the same time that Pratt has focused its organic manufacturing activities on core competencies, where it is truly world-class, it has collaborated with its supply chain and helped introduce many smaller companies to methods and processes that have strengthened the entire value stream. For example, it uses the UTC Supplier Gold program to support supplier development and focuses on aligning with suppliers to produce at the highest levels of quality, cost and delivery performance. Pratt & Whitney shares with suppliers a suite of tools including on-site support and readiness assessments. An example of the company’s commitment to supplier development is the 200 engineers deployed by Pratt & Whitney to work directly with suppliers to help them build capacity and improve metrics through the Supplier Gold program. These initiatives help suppliers be more competitive across their entire customer base and operate successfully even in high-cost manufacturing locations such as Connecticut.

Based on a 12-month sustained performance at the “gold” metric performance level, suppliers earn the designation that includes business rewards such as more favorable commercial terms, lower buffer stock requirements and directed requests for quotes on new work. Pratt & Whitney gold suppliers have 27% better on-time delivery than underperforming suppliers; and they produce conforming parts 99.99% of the time, which is significantly better than underperforming suppliers.

Not all of these suppliers are themselves manufacturers. Some of them provide services such as logistics and software engineering. Collectively, though, they comprise the model for modern manufacturing that provides the most conducive circumstances for companies such as Pratt & Whitney to remain globally competitive,
These parts were made using additive manufacturing technology now in wide use across the aerospace industry. Pratt & Whitney must apply new technologies such as additive manufacturing, robotics and powder metallurgy to its manufacturing processes in order to meet customer expectations for performance and quality.
When Henry Ford constructed his River Rouge automobile plant near Detroit a hundred years ago, self-sufficiency was considered a virtue among manufacturers. In addition to producing all the parts needed to assemble a Model-T, the Rouge complex made its own steel and generated its own electricity, eventually employing a workforce of more than 100,000 at the mile-square site. During the postwar period, though, Ford executives came to realize that a vertically-integrated enterprise could never be as efficient as one focusing on a few core competencies. So the company gradually shifted to reliance on a network of suppliers for many parts and components. Every major manufacturer that has managed to survive in today’s globalized economy does the same, including Pratt & Whitney.

Pratt & Whitney made well over 50% of its parts in-house during the company’s last major production ramp-up in the 1970s and 80s. That number is now roughly 20% because the company shifted to a focus on lean manufacturing while partnering with suppliers to help address issues related to delivery, quality and cost. In many cases, small and medium-size suppliers are more efficient at manufacturing certain parts, enabling Pratt to focus on its core competencies and the proprietary elements of design and production. But that means the company must carefully monitor and develop its supply chain, investing in training and technology to continuously improve supplier performance.

Pratt’s collaborations with its supply chain involves a number of well-known manufacturers in their own right, such as the Alcoa company that supplies precision aluminum parts for PurePower geared turbofan engines and the F135 high-performance fighter engine. However, most of the companies in Pratt & Whitney’s supply chain are small and medium-size firms that specialize in the production of particular parts. Small though they may be,
Pratt & Whitney’s suppliers have worked together within a model that has yielded unsurpassed quality and product cost.

Thus, the supply chain has become integral to Pratt’s business model. Some experts refer to the close coupling of suppliers and system integrators within this decentralized model supporting modern manufacturers as an “extended enterprise.” As the term implies, in the new model, system integrators — like Pratt & Whitney — become managers of a value stream in which a chain of specialized organizations work with general manufacturers as if they were all part of the same far-flung enterprise.

In Connecticut, more than 90 key product suppliers who provide the company with critical components and parts for the PurePower geared turbofan family of commercial engines and F135 military engines work closely with Pratt & Whitney. Many of these companies have reputations of their own across the region. They include Eastford, Connecticut-based Whitcraft, with hundreds of employees, which supplies parts and assemblies for the PurePower engine platform; Windsor-based Aero Gear, which employs more than 100 people and supplies Pratt & Whitney as well as the other major aerospace integrators; and Polamer Precision, in New Britain which manufactures complex bearing-compartment hardware for the PurePower geared turbofan engine family.

J&L Machine Company, Inc., a small, family-owned supplier located in Manchester, Connecticut, 15 minutes from Pratt & Whitney’s headquarters, is an example of the highly skilled, disciplined suppliers.
Pratt & Whitney seeks. J&L produces flight critical rotating engine hardware for the PurePower geared turbofan engine and other high-performance engines. The company has a 38-year relationship with Pratt & Whitney, the past 16 as a direct supplier, and has earned UTC Supplier Gold status each year since 2009.

J&L has embraced the quality systems that are a foundation of the Supplier Gold process because they add structure and discipline, and benefit the entire organization — from preventative maintenance through product quality and delivery. A high level of trust has built up between the two companies over the years, evident in the teaming involved when Pratt & Whitney engineering worked closely with J&L to ensure quality standards were met and cost targets hit for the 70-plus parts the supplier was tasked to develop for the PurePower engine. Because of the strong relationship between the two companies, collaboration in the product development phase has eliminated potential issues as parts move into production.

In addition, the long-term contract agreement that J&L has with Pratt & Whitney on the PurePower program has allowed them to make significant investments in people, infrastructure and machinery in advance of the engine ramp-up. Inspection capacity, for example, has doubled because of the agreement. That contract stability also has had a trickle-down effect to J&L’s suppliers, who have benefited from the promise of business and been able to make similar dramatic investments in their operations.

Another highly-regarded manufacturing company that works with Pratt & Whitney on delivery issues is Reno Machine in Newington, Connecticut which developed a process to machine fan-case liners after they have been installed for a higher-quality product with much tighter tolerances. Problem-solving suppliers such as Reno are clearly an integral part of Pratt & Whitney’s value stream, and their roles are critical to the manufacturing base. Moreover, their employees are as much a part of the community and contributors to the economy as when these jobs were part of Pratt & Whitney’s employee base.

Modern aircraft engines contain thousands of parts engineered to very precise tolerances. The Pratt & Whitney employees who assemble products like the PurePower geared turbofan operate in a zero-defects environment that requires exceptional discipline and attention to detail.
This is why supply-chain management has become a vital part of the Pratt & Whitney culture. The company sets demanding standards regarding the volume, quality and timeliness of deliveries, and then rigorously tracks supplier performance to assure commitments are being met. Any significant deviation from the plan by key suppliers can have serious consequences, because the just-in-time logistics system supporting production processes has minimal slack or backup inventory. To guard against suppliers faltering and thereby impairing the company’s performance, Pratt & Whitney has implemented a no-single-point-of-failure strategy by establishing multiple sources and sites, and other risk mitigation initiatives. It also insists on complete transparency concerning supplier operations and finances so there is early warning of any impending problems.

Because Pratt & Whitney and its supply chain believe that credentialing the workforce is the key to America’s future as manufacturing becomes more advanced, the company has invested in relationships with community colleges and universities to strengthen skills. One example of Pratt & Whitney’s interest is seen through a cutting-edge company-paid machinist training program developed with Asnuntuck Community College in Enfield, Connecticut. Pratt & Whitney worked with its union and the college to develop the curriculum, which employees take advantage of to build their skills. The college is free to market the program broadly to students outside of Pratt & Whitney, as well, helping train people who will contribute to the value stream, either at the company itself or within its supply chain. Another example is Goodwin College located next door to Pratt & Whitney’s East Hartford main headquarters. The school recently began teaching a five-week Inspection, Quality and Technical Drawings training program for Pratt & Whitney employees.

Further to this investment, the company developed partnerships with local universities, including Central Connecticut State University (CCSU), University of Connecticut (UConn) and the University of Hartford. The program at CCSU includes scholarship support, academic advising and mentoring, career and business expertise, job-shadowing opportunities and summer and/or academic year work experiences for future manufacturing and engineering quality professionals. The company is supporting a Center for Manufacturing and Metrology that is also aimed at training for quality professionals. The investment at UConn in an Additive Manufacturing (or 3-D printing) Center focuses on fundamental and applied-research initiatives in the field. UConn’s primary research is in the field of advanced sensors, diagnostics and controls.

Such efforts help keep Connecticut in the top tier of states for aerospace employment, despite the factors that present cost and operational challenges. An example of how the public sector can participate in supporting manufacturing training, centers of excellence can be found a little farther to the north, in the state of Maine, where Pratt & Whitney has a plant whose mechanics avail themselves of a free workforce-training program at York Community College that is funded by the state’s Maine Quality Centers Program. Also in Maine, the company is reaching even further into the developing talent pool through a National Tool and Machine Association apprenticeship program that gives students at Thornton Academy, a public technical high school, onsite training at the company’s North Berwick plant.

With production of large military and commercial engines expected to surge from 800 in 2015 to 1,800 by 2020, Pratt & Whitney has signed around 200 long-term agreements with a projected expenditure of more than $20 billion. Assuring that the supply chain performs smoothly is a central consideration in Pratt’s business plans. The company tracks the movement of thousands of different engine parts through the supplier network 24 hours per day, seven days per week from dedicated Operations Command Centers. Pratt engineers work closely with suppliers to maximize their efficiency, and thereby help them to secure other customers who make it easier to amortize the cost of investment in technology and training. The goal is a seamless supply chain that continuously improves quality and efficiency while setting the global standard for aerospace manufacturing.
CONCLUSION: THE FUTURE IS PROMISING IF MANUFACTURERS CONTINUE TO IMPROVE

The years since the Cold War ended have been marked by significant challenges for American manufacturing. Buffeted by global forces beyond their control, many companies have elected to either exit the sector or source their products overseas. Industries in which America once led the world, such as steel and autos, have been humbled, while the U.S. trade balance in manufactured goods — including high-tech products — has steadily deteriorated. The urban decay that already afflicted many former manufacturing centers in the Northeast and Midwest before the collapse of communism has progressed to a point where formerly thriving communities face bankruptcy.

National media have reported these depressing trends in great detail. What has been largely missed, though, is the nascent renaissance in American manufacturing that has taken hold as companies adapted to the forces reshaping their markets. This story is not just about the return of manufacturing jobs from overseas or the rise of Silicon Valley; it is also about how enterprises with long histories in manufacturing have learned to revitalize their business models, thereby preserving global leadership in important industries. Pratt & Whitney, founded in 1925, is one such company; Boeing (founded 1916), Caterpillar (1925), and Ford (1903) are others. By embracing the imperative of continuous improvement, these companies have weathered the storm of change spawned by globalization and digitization to emerge as dominant, disruptive players in the world economy. Their brands are every bit as potent as those of Apple and Intel.

This study has detailed some of the adaptations that such companies have made to stay on top — the shift from vertically-integrated organizations to businesses focused on core competencies; the embrace of lean manufacturing techniques; the adoption of an extended enterprise model relying on best-in-class suppliers; and the use of new information technologies to monitor workflow and performance.

Collectively, these practices epitomize what modern manufacturing is all about, and explain why it is possible for companies like Pratt & Whitney to thrive while operating in locations where costs are high, regulations are demanding, and politics are sometimes described as dysfunctional. The modern manufacturing enterprise is all about adaptation because the pace of change demands this flexibility of companies for their survival.

Pratt & Whitney has weathered the storm better than most, and now stands poised to execute a surge in production of new propulsion technology that will transform the commercial-transport and military-aviation sectors. But in a world where rapid change has become pervasive, the definition of manufacturing success is constantly shifting. Like the frontier of early American history, the goals to which American manufacturers must aspire keep moving. Under non-stop pressure from foreign competitors, U.S. manufacturers must grow leaner, more agile, and more innovative to preserve the gains they have wrested from an unforgiving global economy. This will require at least three things: steady investment in new technology, continuous training of workers in new manufacturing techniques, and a willingness to take full advantage of low-cost, high-quality suppliers no matter where they may be located around the world.

In Pratt & Whitney’s case, the technology investments will be made in a variety of areas such as 3-D printing, powder metallurgy and robotics — all of them enabled by new information technologies. The worker training will entail close cooperation with suppliers and academic institutions to assure skill levels consistent with production requirements. And the strategy of turning to suppliers for previously organic functions will be critical to growing the enterprise as the company goes forward. Skillfully implemented,
this strategy will create thousands of new, high-paying jobs as Pratt ramps up its engine production. In economic terms, it does not matter whether these jobs are located within Pratt & Whitney or within its supply chain.

As state and federal political leaders increasingly grasp what it takes to remain competitive in the global economy, lawmakers in Pratt’s home state of Connecticut have come to more fully appreciate the role that the company plays in stimulating the regional economy. Lawmakers in Washington, though, are a little further removed from the daily challenges that American manufacturers face.

One of the most important areas where the public and private sectors must work together is to reduce the bureaucratic burden on suppliers. Pratt & Whitney and its parent company United Technologies are involved in the International Aerospace Quality Group, a consortium of leading aerospace companies that focuses on making things more efficient for the supply chain as everyone uses the same language and complies with the same requirements. Government entities could go further by incentivizing companies through tax incentives or other means to enable their suppliers to invest in capital equipment, hiring and labor training.

Moreover, through the U.S. Commerce Department, Small Business Administration and other field agencies, there is opportunity to help qualify suppliers in adjacent industries so they build a broader customer base that includes aerospace. While Pratt & Whitney is already investing to an extent in centers of excellence that assist suppliers with business development, there is more work that can be done here, too, with the promotion of research labs and Commerce Department field services to make them more visible to the supply chain.

Market forces will always be the arbiter of business success, and as the public and private sectors focus their resources collectively, decisions governing taxes, regulations and foreign trade will enhance U.S. competitiveness. As policy makers and legislators in Washington become more aware of the symbiotic relationship between the public and private sectors, the outlook for American manufacturing will brighten.
Pratt & Whitney’s East Hartford testing and assembly facility has been in continuous use since it was built in the 1920s. However, as the engine pictured below illustrates, the products it manufactures have changed radically, as have the skills, technologies, processes and work culture required to remain at the forefront of the aircraft-engine industry. Pratt has stayed ahead while competitors faltered by continuously innovating and adapting.
Ex-Im Bank: How a Small Agency Delivers Big Benefits For America's Economy
Loren Thompson, February 2014

Ensuring The Resilience of the U.S. Electrical Grid
J. Michael Barrett, Jeff Harner and John Thorne, January 2013

Reversing Industrial Decline: A Role For the Defense Budget
Loren Thompson, August 2009

Powering JSF: One Engine Is Enough
Loren Thompson, January 2008