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Industry Study

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Manufacturing Industry

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MANUFACTURING 2015

ABSTRACT: The 2014/2015 Eisenhower School for National Security and Resource Strategy Industry Study for Manufacturing contends that the U.S. manufacturing industry remains a key driver of the U.S. economy and the nation's Gross Domestic Product (GDP). This makes the manufacturing industry an important cog in the "wheel" of national security. In the most recent past, manufacturing has had a resurgence in the United States. There is a new "advanced" era of manufacturing in America that is very different in its opportunities and requirements than what most typically think of as the manufacturing industry. This resurgence has been the result of technology advancements, an influx of automation and new procedures, and innovative methods of production and supply chain management. This new era, while full of possibility, also highlights challenges that must be addressed within the industry, government policy, and the broader American society in order for the United States to fully realize available opportunities in a very competitive international environment. This study identifies the areas listed below as the central challenges that must be addressed if the United States is to succeed in capturing the promise of a new era of advanced manufacturing. This study also provides corresponding recommendations for industry and government action to:

1) Address human capital needs,
2) Improve the business climate, including appropriate regulation, and
3) Improve the physical and intellectual infrastructure needed to support modern manufacturing.

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PLACES VISITED

Domestic:
Carpenter Latrobe Specialty Metal, Latrobe, PA
Clark Metal, Blairsville, PA
Ford Rouge Factory, Dearborn, MI
Ford World Headquarters, Dearborn, MI
Honda Manufacturing of Alabama, Lincoln, AL
Hyundai Motor Manufacturing, Montgomery, AL
Kennametal, Latrobe, PA
Kongsberg, Johnstown, PA
Letterkenny Army Depot, Letterkenny, PA
Lightweight Innovations for Tomorrow (LIFT), Detroit, MI
Manufacturing Association of South Central Pennsylvania, Latrobe, PA
Mercedes Benz Factory, Vance, AL
National Center for Defense Manufacturing and Machining, Blairsville, PA
National Institute of Standards and Technology (NIST), Gaithersburg, MD
North American Höganäs, Hollsopple, PA
Northrop Grumman Electronic Systems, Linthicum, MD
Volvo, Hagerstown, MD
Washington DC Auto Show, Washington DC

International:
Defense Acquisition Program Administration (DAPA), Seoul, Korea
Hyundai Motor Ulsan Plant, Ulsan, Korea
Hyundai Rotem Changwon Factory, Changwon, Korea
Hyundai Steel, Dangjin, Korea
Joint U.S. Military Assistance Group – Korea (JUSMAG-K), Yongsan, Korea
Korean Trade Investment Promotion Agency (KOTRA) Seoul, Korea
United Nations Command Military Armistice Commission, Camp Bonifas, Korea

INTRODUCTION

This study focused primarily on the auto industry as a proxy for examining the broader commercial manufacturing sector, air radar defense as a proxy for military-specific manufacturing, and an example of a government-run military manufacturing depot for a synergistic view of military and commercial manufacturing. The study also scanned across the supply chain of the automotive industry to understand the financial impacts of the various tiers of suppliers. The air defense radar portion of the study was circumscribed due to contract issues that complicated access to key programs, but some exposure was provided to other defense manufacturers. The methodology included full seminar team visits to manufacturing companies listed above, as well as individual research into specific areas of manufacturing.

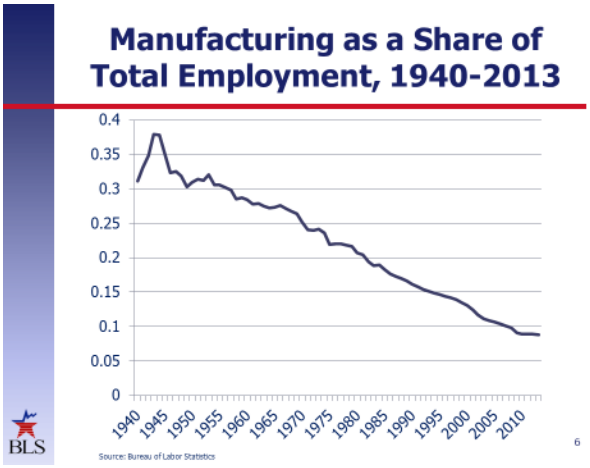
THE INDUSTRY DEFINED

The U.S. manufacturing sector remains a key driver of the U.S. economy, accounting for 13% of the nation's Gross Domestic Product (GDP).[1] Manufacturing is a very broad and diverse industry sector made up of many different types and sizes of companies, encompassing everything from relatively low-tech operations with just a few employees, to large, highly sophisticated multi-national companies on the cutting edge of science, innovation, and automation. While accounting for only 9% of U.S. employment, 300,000 U.S. manufacturing firms produce roughly $2 trillion in annual output. Approximately 98% of U.S. manufacturers are small businesses, 75% of which employ under 500 people, but in total account for more than one of every three manufacturing workers. [2,3] Manufacturing supports two-thirds of private sector R&D, and employs the vast majority of U.S. scientists, engineers, and technicians, making it the prime driver of knowledge production and innovation in the United States.[4]

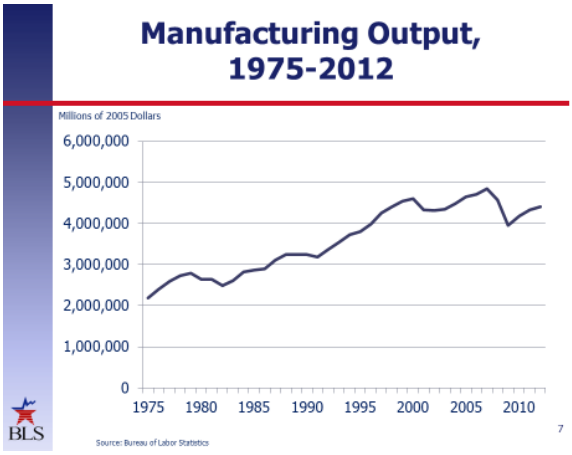
The automotive industry (including vehicles and parts), on which this study primarily focused, is the nation's largest manufactured goods export sector with $125 billion in exports in 2013.[5] The North American auto industry set its third largest production record in 2014, manufacturing over 17.5 million light vehicles (passenger cars and light trucks), of which 11 million were manufactured in the United States.[6] Manufacture for export is accounting for an increasing share of this production. Automakers in the United States directly employ 322,000 people, and a further 805,000 are employed by their Tier 1 component manufacturers.[7] More than two million intermediate jobs are dependent upon automobile manufacture.[8] Estimates of the total economic impact of auto manufacturing in the United States range as high as 7.25 million private sector jobs with a compensation of $500 billion when dealerships and indirect job impacts are considered.[9] In the period 2010-2014 automakers announced $46 billion in new investments for automobile manufacture in the United States.[10] Total foreign direct investment in the auto industry totals $74 billion.[11] These investments, when combined with skilled labor, have yielded an increasingly productive and competitive industry.

CURRENT CONDITION

While manufacturing is significant in terms of employment and the U.S. economy, in the post-WWII era American manufacturing has generally been seen in the popular conception as contracting. The graph at right from the Bureau of Labor Statistics illustrates that employment in manufacturing has steadily shrunk relative to the overall U.S. economy over the past decades.[12]



According to the October 2014 report to the President entitled *Accelerating U.S. Advanced Manufacturing,* U.S. strengths in manufacturing innovation and technologies that have sustained American leadership in manufacturing in the past are under threat from new and growing competition abroad.[13] The United States is now second to China's $2.6 trillion annual manufacturing output,[14] lags behind comparator countries such as Germany and Japan in manufacturing sector innovation, and has relinquished leadership in high-tech industries that employ highly-skilled workers.[15]



However, that is only part of a complex story; a story that has generally been told as one of relative decline, but that is now being re-written as one of revival. As shown at right, with the exception of the "Great Recession" period in the first decade of this century, manufacturing output has grown steadily over the past 40 years.[16]

With increases in technologies, an influx of automation and new procedures, and innovative methods of production and supply chain management, a new type of more efficient and productive "advanced" manufacturing exists today that looks very different from the dark, dirty, and difficult factory environments that many movies portray. According to the President's Council of Advisors on Science and Technology (PCAST) *Report to the President on Ensuring American Leadership in Advanced Manufacturing*:

> Advanced Manufacturing is a family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b) make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences, for example nanotechnology, chemistry, and biology. This involves both new ways to manufacture existing products, and especially the manufacture of new products emerging from new advanced technologies.[17]

The U.S. automotive industry is dynamic and constantly shifting and is a major entity in the advanced manufacturing environment. Traditionally, the Detroit 3 domestic automotive firms (General Motors, Ford, and Chrysler) were the dominant industry force particularly in the U.S. Midwest, which was historically the undisputed home of the industry. However, with the entry of international firms (BMW, Honda, Hyundai-Kia, Mercedes, Nissan, Toyota, and Volkswagen) and their investments across the country, the industry is now more vibrant and complex. Decades of intense competition from many rival automakers have led to increased quality and choices for consumers. These changes have led to new job opportunities and expanded production to new locations.[18]

The United States has experienced a surge in auto exports since the Great Recession, made possible by restructuring actions of the Detroit 3 that made them more competitive internationally. Lower wages relative to Japan and Europe, a relatively weak dollar through 2013, high productivity, high quality, and a favorable investment environment have all encouraged international automakers to expand U.S.-based manufacturing operations, allowing for greater capacity for export beyond the NAFTA region. According to the Organization for International Investment (OFII), from 2007 to 2012, foreign investment in U.S. manufacturing increased from $270 to $493 billion, led by the auto industry.[19]

Many manufacturing companies are also "reshoring" jobs, or bringing previously outsourced jobs backs to the United States. Companies such as Ford, Caterpillar, and GE are moving an estimated 20,000 manufacturing jobs back to the United States from Asia and Mexico.[20] A major reason for reshoring jobs is that wages in formerly low cost countries have increased while U.S. real wages have seen little growth. A more flexible and productive workforce and intensive use of automated manufacturing methods have reduced the importance of labor costs when choosing to produce domestically or abroad, while other factors such as freight and energy costs have become more important.[21]

CHALLENGES AND RECOMMENDATIONS FOR INDUSTRY AND GOVERNMENT ACTION

To fully realize the promise of a new age of advanced manufacturing America needs solutions to the challenges faced in U.S. manufacturing. This study concludes that the key challenges can be grouped into three categories: addressing human capital needs, improving the business climate including appropriate regulation, and improving the physical and intellectual infrastructure needed to support modern manufacturing. Recommendations are made for each of these areas.

Addressing Human Capital Needs: As the automotive manufacturing industry and other sectors of the manufacturing industry migrate towards less labor intensive processes, a different skill set is required. No longer are companies able to take largely unskilled and uneducated workers and simply train them to execute specific tasks. Instead companies now require workers with a higher education level to enable them to understand and manage complex machines and processes. An outmoded image of manufacturing, combined with needs for higher-skilled workers has produced a manufacturing skills gap which constitutes a missed opportunity for job-seekers, and a strategic threat to the sector. As with many industries, one of the most important inputs is people, thus

many of the students in this industry study focused on various aspects of the human capital needs challenge. The recommendations to address the human capital needs challenge focus on areas such as: improving the image of manufacturing, STEM education solutions, improving the quality of the workforce, and immigration reform to name a few. These recommendations are addressed in detail in the "Essays of Major Issues" section of this paper.

Efficient and Appropriate Regulations: Often referenced when discussing the challenges of the U.S. manufacturing sector is the concept of a "regulatory burden." The National Association of Manufacturers (NAM) contends that, overall, U.S. manufacturing firms bear an estimated $2 trillion in regulatory costs, with the average firm paying $19,556 per year, and many smaller manufacturing firms paying up to three times more than the average.[22] Others have asserted that that litigation, taxation, regulation, healthcare, and energy costs add 22% to the expenses of U.S. manufacturers as opposed to the rest of the world.[23] On the other hand, evidence gathered during this study shows that regulations (i.e. fuel efficiency and EPA standards) have also driven innovation and aided in the U.S. migration towards advanced manufacturing by protecting both employees and the environment, as well as encouraging R&D and investments in capital improvements. The manufacturing sector is in the position of being responsible for bearing the bulk of the costs of regulation, while only deriving, indirectly, a fraction of the benefits that accrue to society as a whole.

Even though manufactures recognize regulations are put into place to protect workers' health and safety; the cumbersomeness and complexity of the rules and laws have presented many challenges to doing business and competing on the global scale. A common theme in the meetings conducted for this study related to public participation and transparency in regulatory formation. In several different areas covering regulation and tax policies, the top concern expressed by manufacturers was uncertainty about future changes that are likely to affect their planning. Several vehicle manufacturers visited expected additional required reductions to emissions, but uncertainty about levels and timeframes was a key concern. Without this information, it becomes impossible for firms to make fully informed decisions on capital investments and future workforce needs.

Recommendation: Increase Consultation, Transparency, and Cost-Benefit Analysis of Regulations. The increasing level of complexity and interdependence of processes presents a significant challenge for implementing new regulations and performing compliance validation. It will remain critical that government regulations and policies address the externalities of the system, are fairly and efficiently implemented, and continue to play a key role in ensuring the U.S. manufacturing industry innovates rather than stagnates.

Trade Policy: Trends in the North American automobile industry illustrate the importance of trade policy. The recent rapid rise of Mexico's automobile industry primarily to serve export markets points to lost opportunities for U.S. manufacturing and a potential long-term threat to U.S. manufacturing jobs and competitiveness. As the productivity gap between the United States and Mexico narrows for auto manufacturing, securing free trade agreements will be critical to expanding U.S. auto and other complex manufactured exports. Mexico has concluded 11 free trade agreements which provide access to 44 countries in North and South America, Europe, and Asia.[24] By comparison the United States only has agreements with 20 countries, and negotiating progress on both the Trans-Pacific Partnership (TPP) and Trans-Atlantic Trade and Investment Partnership (TTIP) is troubled. As a result, 80% of Mexican-built cars are exported, and the

volume of these exports is only likely to increase.[25] The TPP and TTIP free trade agreements provide an opportunity for the United States to establish and enhance our trade relationships and increase our exports in the European and Asia-Pacific markets. The success of past free trade agreements, with documented increases in U.S. exports to partner nations, demonstrates the potential benefit that could be reaped through TPP and TTIP. As an example the Korea-U.S. Free Trade Agreement (KORUS FTA) increased U.S. exports to South Korea during its first two years. Manufactured exports increased by three percent, including an 80% increase in passenger vehicles and services.[26]

Recommendation: The Administration must increase transparency and broad stakeholder engagement during negotiations of the TPP and TTIP to ensure the final agreements are publically supported, executable, and without unintended consequences. **Congress should support the TPP and TTIP, and provide fast-track authority** which is essential to the Administration's ability to build the trust with partners necessary to get the best deals.

Off-shoring/Re-shoring: The principal vulnerabilities caused by outsourcing are atrophy of domestic manufacturing capacities and skills, which could be a strategic threat. Original equipment manufacturers (OEMs) and government must increase understanding that key manufacturing capacities and capabilities lost to the nation through off-shoring can be extremely expensive and time-consuming to rebuild domestically, and that overdependence on foreign sources of supply and/or labor represents a strategic threat to businesses and the nation. Government and business should partner to create policies and incentives that retain key manufacturing capabilities domestically, thus protecting U.S. economic stability.

R&D Incentives and Infrastructure: America's innovation advantage is being eroded relative to key competitor countries. The current U.S. government approach to stimulating research and development (R&D) activity is inadequate for maintaining a U.S. competitive advantage in manufacturing innovation. For the United States to maintain technological leadership, and regain lost ground in advanced manufacturing, there will need to be much more of a R&D investment partnership between the government and the private sector. The need for government to incentivize others to engage in desired behaviors without having direct control makes its effective use of the tax policy lever highly important and consequential. *Additional information and specific recommendations are provided in an essay below examining this issue*.

Physical Infrastructure: American manufacturing and our potential for increased prosperity is directly impacted by the deterioration of our nation's infrastructure. Lack of appropriate levels of investment and short sighted policy decisions by law makers have led to a diminished capacity to move goods, which in turn hinders U.S. manufacturing competitiveness. The United States is quickly being outpaced by global competitors who are investing more of their GDP into repairing and building improved modes of transportation as well as developing more effective and efficient long-term infrastructure and resourcing strategies to support their economies. As one example, U.S. ports that handle 76% of America's $460 billion in international exports[27] are lagging in their ability to accommodate newly designed, larger, container ships that are increasingly carrying global trade. According to the National Association of Manufacturers, 70% of its members state

that America's infrastructure is not up to par and they need a more quality system in order to be competitive.[28] The deterioration of the over 47,000 miles of interstate highways, more than four million miles of roads, and major ports that are the most common arteries on which U.S. manufacturers depend to source inputs and get goods to market presents a strategic threat to the nascent resurgence of American manufacturing. Unless significant investments are made into infrastructure solutions there will continue to be a bottleneck in transporting goods and supplies relating to manufacturing, which will significantly limit U.S. ability to realize the potential for economic growth from the manufacturing sector.

Recommendation: Develop a strategic national infrastructure plan. Similar to the Department of Defense's Quadrennial Defense Review or the newly mandated Quadrennial Energy Review, the President should mandate a Quadrennial Infrastructure Review that takes a holistic, multi-year view of the nation's infrastructure to prioritize investment. The Quadrennial Infrastructure Review would be a focused, actionable process that all branches of government and other stakeholders can participate in to ensure America's infrastructure is not only on par with our global competition but leading the way.

Recommendation: Increase government infrastructure funding. The gas tax must be raised as a near-term solution to arrest the deterioration of the U.S. transportation infrastructure. The gas tax supports the nearly bankrupt highway trust fund, and has not been raised since 1993 when the price of oil was 60% less than what it is today. Longer-term actions must also be taken. Congress should pass the Grow America Act and the American Jobs Act. The Grow America Act is a four year, $302 billion dollar proposal designed to address the shortfall in the highway trust fund and provide $87 billion to meet the nation's backlog of deficient bridges and aging transit systems; it provides $10 billion toward improving the movement of freight; and provides $92.1 billion to repair and reduce traffic congestion on the National Highway System.[29] The American Jobs Act would also ease the strain on our infrastructure and provide critical relief to manufacturers. This bill calls for the investment of $105 billion in infrastructure; $50 billion of which is earmarked to improve highway, highway safety, transit and passenger rail activities.[30] Of that $50 billion, $27 billion is set aside to make the nation's highway systems more efficient for passenger and commercial transportation.

Energy Policy: The manufacturing sector is large consumer of energy, and consequently, domestic energy policies can have a profound impact on its global competitiveness.[31] Currently, the fracking-enabled oil and natural gas supply boom is providing a major cost advantage for the entire U.S. manufacturing sector. Steel and chemical producers have seen a significant impact on their competitiveness. Other industries that benefit include plastics, fertilizers, and pharmaceuticals, for which natural gas serves as feedstock. An abundance of low cost natural gas is resulting in a shift away from coal for electricity production, reducing electricity costs for U.S. manufacturers.[32] The low price of energy due to the shale boom may result in up to one million new manufacturing jobs, according to PricewaterhouseCoopers.[33] The near- to medium-term decline in energy costs driven by shale oil and gas and global petroleum overcapacity is not expected to last for the long-term (10-15 years). The price for a barrel of oil is expected rebound to the equivalent of $90 per barrel by the 2020's.[34] Efficiency is the most economical means to lower energy costs over the longer-term, and addressing the energy use of structures could significantly reduce consumption while producing jobs. Refitting buildings in the United States over the next ten years could create up to 127,000 manufacturing jobs.[35] Low carbon energy –

solar, wind, and other renewables are beginning to demonstrate commercial viability and command annual global investment on the order of $260 billion annually.[36] Meanwhile the link between economic growth and energy consumption has been disrupted by efficiency increases. The U.S. economy has grown by 9% since 2007, while the consumption of petroleum products has fallen almost 11% in the same period.[37] The combined potential of energy derived from increased efficiency, shale resources, and storage-enabled renewable production promises to boost both traditional and advanced manufacturing in the United States.

Recommendation: Speed development of renewable energy resources and energy efficiency measures to transition to a low carbon economy through increased tax incentives to utilities and manufacturers. A portfolio of policies is necessary to reduce the cost of renewables such as solar and wind energy to spur demand. Targeted tax incentives and subsidies are necessary to support high-risk R&D in production and storage technologies and enable wide-scale adoption of renewal energy sources.[38]

OUTLOOK

This section discusses the future health of the U.S. manufacturing industry and its support of national security resources requirements over short-term (1-5 years) and long-term (10-20 years) periods. It also examines potential issues in an austere DoD budget climate during this timeframe. Finally, it reviews the U.S. manufacturing base as a whole and its relative position in the global marketplace and discusses potential improvements to advance the industry.

The Manufacturers Alliance for Productivity and Innovation (MAPI) forecasts U.S. manufacturing production growth of 3.5% in 2015, 3.9% in 2016, and 3.1% in 2017.[39] It attributes this projected growth to drivers such as natural gas infrastructure, the housing supply chain, transportation infrastructure, factory automation, medical care expansion, and increasing confidence.[40] This growth expectation is further supported by Trading Economics, which projects the U.S. manufacturing purchasing managers index (PMI) to range around 55-56 through 2050.[41] The index represents the economic health of the manufacturing sector, and is based on five indicators: new orders, inventory levels, production, supplier deliveries and the employment environment.[42] An index score of greater than 50 represents expansion of the manufacturing sector, a score less than 50 represents a contraction, and a reading at 50 indicates no change.[43] Based on this information, the overall health of the U.S. manufacturing appears solid in both the short- and long-term.

In order to understand how the manufacturing industry health is juxtaposed against national security, it is necessary to understand what about the manufacturing industrial base is significant to national security. This job falls to the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (DASD (MIBP)), which was established by section 896 of the Ike Skelton National Defense Authorization Act (NDAA) for Fiscal Year 2011.[44] A nearly 200 page DASD(MIBP) October 2013 annual report to Congress concerning the industrial base, presented a current sector-by-sector, tier-by-tier (S2T2) approach that systematically reviewed U.S. manufacturing and the industrial base.[45] One of the primary concerns in the report is that the continued budget uncertainty will hit smaller, innovative, and niche product companies particularly hard due to a lack of capital resources to withstand the turmoil and ambiguity.[46] In recognition of this concern, the DoD report indicated that its S2T2 approach would continue to emphasize these types of firms in its review, and indeed funding has been provided to a few firms to preserve vital capabilities.[47]

It addition to an exhaustive review of the defense manufacturing and industrial base, the report to Congress also outlines the 34 programs the DOD is fostering in the development of new technologies through the Defense Production Act.[48] Several of these programs are aligned with the Obama Administration's focus on revitalizing American manufacturing. Based on a 2011 *Report to the President: Ensuring American Leadership in Advanced Manufacturing*, President Obama created the Advanced Manufacturing Partnership (AMP) to foster joint industry, academia, and government initiatives to spur U.S. advanced manufacturing competitiveness.[49] Two subsequent AMP reports – *Capturing Domestic Competitive Advantage in Advanced Manufacturing* (July 2012) and *Accelerating U.S. Advanced Manufacturing* (October 2014) – highlighted key areas in need of attention, and made specific recommendations for fostering a revitalization of U.S. manufacturing. The long-term beneficiary of this revitalization will be national security.

As a final point concerning the manufacturing industry with regard to national security, the DoD continues to receive updates on a plethora of industrial base assessments conducted by the Department of Commerce. These are very specific and comprehensive assessments of particular industries. For example, one recommendation called for a review every two years on "future activity in leading-edge integrated circuit (ICs) production to assess any erosion or expansion of domestic capabilities, as few companies can currently fabricate ICs at the leading-edge technology nodes below 65 nanometers."[50] Currently, other assessments are on-going with rocket propulsion and underwater acoustics transducers to name a few.[51]

The future appears promising for the U.S. manufacturing industry and its continued role in U.S. national security. According to the Boston Consulting Group, inexpensive energy, along with restrained labor costs, make the United States a “rising star” amongst manufacturing nations.[52] Low U.S. energy costs are also a key factor in decisions of multinationals to “reshore” manufacturing activities and jobs, due to an attractive overall U.S. business climate considering labor flexibility and cost differentials, transportation costs, and currency stability.

Still, America can do more. Though it enjoys an overall 3rd place when it comes to business competitiveness when measured against 144 other countries according to the 2014-15 Global Competitiveness Report, there were three areas that survey responders highlighted as problematic factors for doing business in the United States.[53] These areas were: tax rates, tax regulations, and inefficient government bureaucracy.[54] While these areas are much discussed in Washington DC, little beneficial progress has been made. However, as the Brookings Institution notes, the Obama Administration has not given up as the Fiscal Year 2016 Presidential budget submission "contains several useful ideas for much needed corporate tax reform. And while the rates proposed are quite unrealistic, perhaps these are the President's opening bids in what could become a lengthy negotiation with Republicans in Congress."[55] This is generally encouraging news and the proposals need to be followed up with pragmatic dialogue on behalf of both the White House and Congress to ensure these areas are addressed for the future competitiveness of U.S. manufacturing.

ESSAYS ON MAJOR ISSUES

America Must Cultivate and Attract the Human Capital Needed to Grow Advanced Manufacturing

The phrase "dirty and dangerous" is commonly invoked when one envisions manufacturing as a potential profession. Black and white images of early twentieth century shop floors with large and loud machines whirring endlessly permeate one's thoughts of this industry. This impression could not be further from the reality, as advanced manufacturing techniques have ushered in an era of high technological skills and safe working environments that demand not only adept and intelligent workers but also those gifted with both innovation and drive to improve their daily manufacturing processes. However, outdated impressions and societal factors that have atrophied the capabilities of native-born American in science, technology, engineering, and math, while at the same time pushing more young people into tertiary education, have produced a skills gap and vacancies in manufacturing.

The Society of Manufacturing Engineers predicts that the shortfall of skilled factory workers could increase to three million jobs by 2015 due to pending retirements of older workers and a manufacturing rebound. Another study forecasts a deficit of up to 875,000 machinists, welders, industrial engineers, and industrial machinery mechanics by 2020.[56] Other sources suggest that more than 75% of U.S. manufacturers report a moderate to severe shortage of skilled labor, reducing earnings by up to 11% annually due to increased production costs and revenue losses resulting from skills shortages.[57] Further evidence of a skills shortage can be found in overtime data. U.S. Department of Labor Current Employment Statistics show that average per-worker weekly hours in manufacturing have increased since 2006, while overall worker hours across industries have been decreasing since 2006.[58] This illustrates how companies are being forced to use overtime as a stop gap measure due to the skills shortage.

Replacing the aging U.S. manufacturing workforce with a new generation requires industry to take a more active role. The process can be time consuming, resulting in productivity losses that threaten the positive trend of output per worker that has been key to sustaining some level of American manufacturing competitiveness. Companies can no longer be "free riders" expecting government and future workers themselves to completely bear the responsibility and costs of providing the skilled workforce from which industry profits. In order to best capture the attention and potential interest of new recruits, it is necessary to understand the different generational desires, goals and interests. Programs to enhance workers' job satisfaction in order to increase the retention rate can be cost-effective alternatives to frequently replacing valuable talent.[59] In essence this requires greater attention to, and investment in, workforce development.

A key reason identified through this study for the shortages of the technical and analytical skills needed to support advanced manufacturing in the United States is deficiency in U.S. science, technology, engineering, and math (STEM) education. STEM education has been highlighted as important for national economic development for years, especially in leading manufacturing countries such as Germany and China. In 2009, the Program of International Student Assessment (PISA) ranked 15-year-old U.S. high-school students 18th in mathematics and 13th in science.[60] This shows that U.S school systems need some work in these areas to catch up with even the lesser industrialized nations.

Many advocates, such as the STEM Education Coalition, have identified early exposure as a key component to promoting STEM subjects and encouraging students to pursue STEM-related studies and professions.[61] This has become the norm in countries such as Germany, Japan, and China, which are among the leaders in both STEM education solutions and modern manufacturing. Some studies show that engaging students in STEM subjects at a young age has been shown to promote academic growth and develop early critical thinking and reasoning skills. Such student engagement on STEM at all ages is particularly relevant to helping fill the gap of minorities acquiring key STEM skills.[62]

The historic antagonism of union-industry relations in the United States and structural disincentives to a productive labor-industry sense of shared responsibilities threatens American manufacturing competitiveness. As the success of Germany's manufacturing sector demonstrates, a recognition that labor needs a seat at the table to provide input into managerial decisions and the legislative framework has proven to be successful. U.S. organized labor can and must regain its footing as a balancing force to corporate planning that is often short-term, which can have a prejudicial effect on America's middle class – a resource vital to our national strength.

Benchmarking lessons from Germany: The German model has yielded business success utilizing a more cooperative and symbiotic labor relations systems – a system which views labor more as a vital company asset than the American view of labor as a disposal commodity.

The short-term focus on share prices that seems to drive much decision making of U.S. corporations today also has negative effects on the development of workforce capacity that is necessary for America to realize advanced manufacturing opportunities. It is common to see corporations quote a "fiduciary responsibility to shareholders" as justification for stagnation of workers' wages and layoffs, even during times of high company profits. The result has been the under-development of large portion of American industrial workforce, who without confidence of stability and without an assured development plan have languished in their development potential. Looking long term, there are broader impacts to the American social and economic structure. And so - it is not surprising to hear both Republican and Democratic presidential candidates for 2016 discuss economic inequality as a weakness in our society today.

The World Economic Forum has taken the lead in attempting to quantify the state of labor relations in each country. Each year it analyzes over 100 areas of business development in 144 countries. In the category of cooperation in labor-employee relations, the United States ranks only 43rd of the 144 countries analyzed.[63] This begs the question what can be done to improve this relationship, perhaps leveraging practices from countries in the top 10 of this listing? One example comes from Germany. The German government enacted their Works Constitution Act in 2001 with the acknowledgement that absent Government vision and direction, corporations would lose sight of what is best for whole of society. This law basically mandated a democratic-type process for management decision-making as corporate leadership was required to listen to their workers.

Recommendations

Policy makers and educators must implement meaningful and consistent metrics and standards for STEM program evaluation in order to ensure that students and manufacturing sector employers both get the skills they need to reap the opportunities that a new era of U.S. advanced manufacturing provide.

Increase the participation of underrepresented populations in STEM fields: In STEM professions, women and minorities make up a small percentage of workers in the higher level STEM professions especially in manufacturing.[64] This presents an opportunity to address insufficient supply of skilled workers that is hampering U.S. economic potential, while at the same time providing social mobility and higher earning potential for women and minorities that would yield broader social benefits. The manufacturing industry should invest in human capital development the same way it invests in other forms of capital in order to increase future return by undertaking initiatives to expose minorities to the opportunities for STEM-qualified workers and to develop realistic pathways for minorities to help close STEM skills gaps.

Make a concerted effort to re-shape manufacturing's image to attract new talent. Industry, government, and a wide range of potentially impactful organizations must work more effectively together in a common effort to help students, parents, and those already in the workforce gain a better picture of the realities, and opportunities, of modern American advanced manufacturing. Policies and educational programs enacted at the federal, state, and local levels can go a long way to increasing the desirability of manufacturing jobs. Policies enacted at the federal, state, and local levels can go a long way to increase the desirability of manufacturing jobs to the workforce and the affordability of these same jobs to companies engaged in this industry. Through positive and affirmative policy development and enactment government is a key player towards maintaining health and vibrancy in this sector of our economy. The government does this through the passing of legislation to enable manufacturing growth, (enactment of the Revitalize American Manufacturing Act[65] is a good example), using non-profit partnerships to connect industry with universities, and increasing the availability of tax credits.

A competitive labor market requires increased wages to attract skilled workers. Even though the national average wage for manufacturing lags slightly behind the rest of private sector workforce wages, there are specific high skill job sets for which a lack of trained workers and a lowering unemployment rate have significantly increased manufacturing wages in some states.[66] This increase in wages has given more incentives to enter these manufacturing sectors and thus improved the image by attracting the highly educated/skilled employees. The increase in wages subsides once the supply of workers satisfy the demand levels. Whether wage growth merely slows, or wages then actually decline, depends on market forces.

Industry and government implement programs that attract and retain key talents. Manufacturing firms need to consider long-term development and multiple experiences within an organization, inspiring a sense of purpose and meaning in work, ensuring availability and access to mentors across the company, providing work-life flexibility in a tech-savvy work environment, and providing open social networks that embrace open and honest communication. This can be done by offering workers options in terms of where, when, and how work is to be performed, to allow for the attainment of personal, professional or leadership goals. Additionally firms need human resource and marketing strategies that highlight professional development options such as education, training and mentoring programs to include internships and apprenticeships, and advancement opportunities. Providing paths for lower-skilled workers to develop the types of skills advanced manufacturing needs will help to address labor supply shortages, while also increasing motivation and morale within companies.

Enact comprehensive immigration reform: This country depends upon the innovation and hard work of immigrants and the broken immigration system is threatening this legacy, as well as the competitiveness of the country. The National Association of Manufacturers (NAM) views immigration reform as a global competitiveness issue. In order for U.S. manufacturers to remain competitive, they have to attract and retain quality workers with the requisite skills from a global pool. One solution is the ability for U.S. manufacturers to successfully compete in the global market which is directly linked to the success of U.S. immigration policies. This study agrees with the position of the National Association of Manufacturers that:

> Such reform should include fundamental changes in the method of determining the number of employment-based visas, creating a system with an emphasis on market demands. Reforms would improve the employment-based green card system to keep talent within the United States, streamline and simplify the procedures for the temporary or non-immigrant visa, allow for temporary workers and immigrants to meet the needs of employers without displacing American workers and create other changes to enhance flexibility in responding to demands for the skills necessary to grow America's economy.[67]

Congress should request an in-depth Congressional Research Service study looking at lessons learned from countries with successful labor unions such as Germany to build a stronger labor base. As Business Insider Magazine has noted, the success of the German model is "not simply because they have a strong organized union - rather their empowered union, backstopped by co-determination laws and works councils, influences management of companies."[68] The study should have two focus points:

- Analysis of the state-led effort to reduce the power (membership and finances) of organized labor with "right to work" legislation along with an examination into how the society (declining middle class) is affected by such legislation.
- Benchmark the German methods for labor relations.

Strengthening the Intellectual Infrastructure of American Innovation by Stimulating R&D

American innovation has been a traditional competitive advantage for the United States and U.S. manufacturers. This has been an important driver not only of American prosperity, but also of U.S. military might that owes much to the ability to field technologically superior weapons systems. It is therefore of concern that America's innovation advantage is being eroded relative to key competitor countries. Globalization, domestic social factors, complacency, and political inefficiency have all contributed to put America's manufacturing innovation capacity at-risk. The current U.S. government approach to stimulating research and development (R&D) activity is inadequate for maintaining a U.S. competitive advantage in manufacturing innovation. High corporate tax rates, unclear R&D tax credit rules, and costly capital purchases serve to stifle the investments needed in innovation and new technologies needed to restore U.S. leadership. U.S. tax regulations relating to R&D expenses are complicated and confusing, which mitigates against their effectiveness.

A major problem with the existing Internal Revenue Code Section 41 R&D tax credit is that it has never been permanent. It has expired and been renewed thirteen times since 1981, causing uncertainty that critics argue reduces the credit's effectiveness in influencing business investments.[69] The structure of the current R&D tax credit also undermines its effectiveness. It is an incremental credit, meaning that its value is based on increases of R&D spending above a calculated base of a company's historical R&D spending. This incremental nature slants rewards to companies whose R&D programs are continually increasing, reducing its incentive effect for companies to maintain steady levels of R&D. A 2012 study by the Information Technology and Innovation Foundation ranked the United States twenty-seventh out of forty-two countries in R&D tax incentive generosity.[70]

The trend of the last few decades, and the likelihood of significant fiscal pressures for the foreseeable future, indicate that the Federal Government will not on its own be able to be the driver of R&D investment it has been in the past. For the United States to maintain technological leadership, and regain lost ground in advanced manufacturing, there will need to be much more of a R&D investment partnership between the government and the private sector. The need for government to incentivize others to engage in desired behaviors without having direct control makes its effective use of the tax policy lever highly important and consequential.

Recommendations

Translate the Advanced Manufacturing Partnership (AMP) reports into a national advanced manufacturing strategy that recognizes the essential link between manufacturing R&D and U.S. manufacturing leadership. The AMP series of reports have laid the essential blueprint for a practical and promising strategy. The AMP must be an ongoing process of cooperative public-private re-examination of progress and needs relative to U.S. advanced manufacturing competitiveness in order to maintain momentum and forge a critical mass of engaged leaders who can keep government and private-sector attention on key challenges. It is essential to continue turning AMP recommendations into results like the innovation institutes. The National Network for Manufacturing Innovation (NNMI) network can help to establish standards for new manufacturing products and processes. Benefits from this network can include faster adoption of technology for manufacturing firms that otherwise would not have the know-how on their own.

Increase R&D funding focused on key technologies. Fiscal constraints will require there to be intelligent focus of public R&D funding on areas where it can be most consequential. This cannot be an attempt to project future "winners", which historically has been folly. Instead, the government must use its limited resources to do the basic research that is too risky or long-term for a return-on-investment driven private-sector to undertake, and target applied research funds more toward enabling and leveraging private-sector investments by bridging gaps in the technology development continuum. The AMP recommended prioritizing three potential high-impact technologies: Advanced Sensing, Control, and Platforms for Manufacturing; Visualization, Informatics and Digital Manufacturing Technologies; and Advanced Materials Manufacturing.[71] Congress should also prioritize funding R&D leveraging efforts and platforms such as the Institutes for Manufacturing Innovation.

Enact tax reform that strengthens and makes permanent R&D tax credits. The Section 41 federal Research and Experimentation Tax Credit expired at the end of 2014. The new Congress needs to quickly reinstate the credit, and should simplify it and make it permanent as proposed in

the American Research and Competitiveness Act of 2014 that was left unpassed by the 113th Congress.[72] Increasing the rate for the Alternative Simplified Credit option to 20% is an AMP recommendation[73] that would support small and medium-size business R&D. However, caution is warranted here. With the short-term focus on share prices driving much decision making and many compensation incentives in American corporations, companies have been known to "buy back" some of their publically offered shares with available cash (thus manipulating upward earnings per share and share price) instead of investing in R&D or making capital improvements.[74] Any changes on R&D tax incentives should include a measure where corporate stock buy backs reduce the eligibility to claim R&D tax credits in the same year. Alternatively, Congress should take broader action to reduce incentives to harmful short-term corporate thinking by requiring all executive compensation based on stock sales and share prices to be subject to a mandatory vesting period, on the order of 3 to 5 years.[75] This action would seek to ensure that the long-term (at least 3 to 5 years) benefit of actions is considered by the executives, not just the short-term share impact.

Reform the U.S. patent system to support manufacturing innovation. In conjunction with measures to bolster U.S. R&D, steps should be taken to update and improve U.S. patent laws as part of an overall effort to foster an environment of innovation needed for the United States to regain leadership in advanced manufacturing. Actions should include: Full Congressional passage of the Innovation Act passed by the House of Representatives in December 2013, codifying into law Executive Actions on patent reform implemented by President Obama, shorten the outdated 20 year length of patents, or tailor the duration of patent protection to the conditions of the specific sector the patent affects, consideration of establishing a "use it or lose it" requirement to keep potential innovations from laying fallow rather than benefitting society.

COMPARISON WITH SOUTH KOREAN MANUFACTURING

The group that undertook this study visited the Republic of Korea (ROK) as part of the Eisenhower School's international study program in order to: a) gain an appreciation of international business and trade, and b) have an opportunity to compare and contrast observed manufacturing from the seminar visits in the U.S. and South Korea. The similarities and differences from tours and visits were hard to quantify because the access to operations, personnel, and financial aspects were very limited due to time constraints and what we perceived as a notable lack of corporate transparency.

In order to supplement the visits, additional research was necessary to draw substantive conclusions. The economic growth of the ROK over the past 30 years has been admirable. A phrase shared with the group was that South Korea has "gone from developing to donor in less than a generation," and it is a feat in which South Korea rightly takes great pride. In fact, the ROK's manufacturing value added as a percentage of GDP was more than twice that of the United States, 28% to 12%, respectively, in 2013. This shows how crucial the vitality of the manufacturing base is to the Koreans.[76] Recently, the Congressional Research Service published a report on how U.S. manufacturing was faring in the international community. Table 1 provides a summary of key statistics from the report on both the U.S. and the ROK.[77]

Table 1

	U.S.	ROK
Total Manufacturing Value Added	**$2,029B**	**$370B**
Growth in Manufacturing (2005-2013)	**5%**	**54%**
Domestic Value in Exports		
- Transport Equipment	**80%**	**65%**
- Electrical & Optical Equipment	**89%**	**53%**
Manufacturing Employment Change (2003-2013)	**-12%**	**-1%**
Real Output per Labor Hour Change (2002-2012)	**53%**	**91%**
Hourly Manufacturing Compensation Cost		
- Average	**$36.34**	**$21.96**
- Motor Vehicles	**$46.35**	**$26.81**
- Textiles	**$23.93**	**$14.45**
Research & Development for Manufacturing		
% of Sales		
- All of Manufacturing	**3.30%**	**1.90%**
- Motor Vehicles	**3.40%**	**2.80%**
- Pharmaceuticals	**22.50%**	**2.50%**
- Office, Accounting, Computing Machinery	**11%**	**3.90%**

Note: Figures from 2013 unless otherwise noted

As seen in Table 1, even though the ROK's manufacturing is a large part of the GDP and has increased rapidly in the past five years, it is only 20% of the United States' manufacturing base. One interesting aspect of the statistics deals with domestic value in exports. This category represents the amount of imported inputs versus the amount domestically produced inputs (not raw materials). In this instance, the ROK uses 35% of imported inputs for its transport equipment whereas the United States uses only 20%. Also, for electrical and optical equipment, the United States only used 11% imported inputs, while the ROK used 47% imported inputs. Essentially, this means that the U.S. supply chain for these two sectors, transportation and electrical optical equipment, is more heavily concentrated in-country. Another intriguing detail, is the difference in wages. While the difference is not surprising, due to ROK's recent development (i.e., burgeoning per capita GDP), it is somewhat unexpected that a firm like Hyundai is finding some competitive advantages of building auto plants in the United States even though average wages in Korea for motor vehicle manufacturing are cited as being almost 40% less than in the United States. However, study visits to Hyundai auto plants in Alabama and South Korea revealed that the U.S. workers made about $20 per hour, while a Hyundai official at the South Korea factory said its workers make $80,000 or more per year (about $38 per hour).

Accounting for these types of phenomenon are aspects that may not be readily apparent on the factory floor, but are measurable. The IMD World Competitiveness Center specializes in such measurements. As one example, the IMD 2014 World Talent Report, amassed surveys across 60 countries and then ranked countries in three broad categories: Investment and Development Factor (how a country develops a potential workforce), Appeal Factor (labor relations, attractiveness to foreign citizens), and Readiness Factor (the overall environment for sustaining and growing a workforce).[78] For 2014, Korea ranked, 43rd, 50th, and 37th, respectively, and 40th overall of the 60 countries.[79] The U.S. ranked 24th, 3rd, and 15th, respectively, and 12th overall of the 60 countries during the same timeframe.[80]

The ROK is well aware of these shortcomings and tries very hard to overcome them. In one report published by the Hyundai Research Institute in 2007, the authors recommended three policy suggestions to the ROK government: improvement of corporate investment environment, enhancement of non-price competitiveness of domestic export industries, and intensifying efforts to attract foreign capital.[81] In fact, the seminar did get to witness, with a visit to the Korea Trade-Investment Promotion Agency (KOTRA), a strong effort to attract foreign investors. Additionally, five essays published by McKinsey & Company in April 2010 suggest that the two other suggestions are being pursued by the ROK as well.[82]

Finally, concerning the R&D investment for manufacturing, the U.S. leads the ROK in the categories highlighted as seen in Table 1. What is not clear from the report is if these figures include government subsidies. Additionally, a study by a U.S. National Institute of Science and Technology (NIST) researcher asserted that the United States falls far behind the ROK in national R&D intensity.[83] One question during the seminar's tour in South Korea was the amount of assistance that the government provides to manufacturing firms within the country. Again, a generalized impression that was made because the companies visited appeared to be "nationalized" (probably due to the fastidious organization and military-type of environment in which they were presented).

It's no secret though that the economic development of the country stems from the Five Year Plan policies of President Park Chung Hee, which sought to quickly industrialize the country by promoting large conglomerate-type businesses called the *chaboel*.[84] The *chaboel*, essentially large conglomerates that are family owned, are alive and well today with such companies as Samsung, Hyundai, and LG. Though many of these companies became financially independent following South Korea's economic boom in the 1980s, there has still been heavy government involvement.[85] As an example, in 2012, Samsung received over $155M (US) from the government and roughly 70% of it was for R&D efforts, while Hyundai received almost $80M.[86]

Still, it is doubtful that government investment in R&D will be the panacea for Korea going forward. The ROK's largest trading partner, and also its biggest competitor, is China. To that end, it will have to find ways to make itself more competitive, not just in terms of technology because it maintains a competitive advantage over China in technological sophistication and product quality,[87] but also in terms of cost. One of the ways that it is doing this is by off-shoring some of its manufacturing to lower-cost countries like India, Indonesia, and Vietnam.[88] This approach is very analogous to the approach U.S. firms took in the 1990s and 2000s (and perhaps still today), and it will be interesting to see if it leads the ROK out of more-labor intensive manufacturing industries, i.e., textiles, furniture, and jewelry, as it has the U.S., and into an era of advanced manufacturing.

In order for the ROK to maintain its manufacturing competiveness with China and internationally, it should examine the three recommendations provided by the Boston Consulting Group from an aforementioned reference: 1) accelerate the speed of technology development, 2) avoid tradeoffs between quality and 3) productivity when entering premium markets, and maximize global advantage by partnering with Chinese companies.[89] Finally, the ROK needs to continue to study its standing in the Global Competiveness Index framework and its rankings in the measured areas in relation to more successful countries. Due to its rapid growth, it has established itself as a "Stage 3" country (highest category and labeled as innovation-driven economy); however, the quick industrial rise may have not allowed particular aspects of their economy to mature.[90] To that end, it must focus on (capture and inculcate) the success that more competitive countries possess for its continued long-term growth.

CONCLUSION

Preserving a vibrant manufacturing sector in the United States remains as important today as it has historically been to maintaining U.S. economic diversity, growth and leadership. Further, the ability to make things in the United States also remains critical to supporting defense production that underpins our national security.

After a difficult period of adjustment to the reality of globalized market forces, American manufacturing is in a solid position from which it could transform into a global leader in advanced manufacturing. The transition to advanced manufacturing has been largely leveraged on the productivity of the American worker. It is thus critical that the United States continues to cultivate domestically, and be able to attract from abroad, the human capital required to realize the possibilities of a new era of advanced manufacturing. Absent bi-partisan support of broader policies and government actions that look toward a long-term horizon there is also the possibility for the United States to lose out to advanced manufacturing competitor countries, who are better able to align their domestic environments and international trade relationships to take advantage of opportunities. The recommendations provided in this paper provide a strong starting point to ensure that the United States remains in a leadership role in the advanced manufacturing industry.

APPENDIX A

Sector	Company Name	Location	What they Do
Auto Manufacturer	Ford Rouge Factory	Detroit, MI	Assemble aluminum body Ford F150 pickup truck.
Auto Manufacturer	Ford World Headquarters	Dearborn, MI	Management of Ford North American truck operations, the profit center of the Ford Motor Company
Auto Manufacturer	Honda Manufacturing of Alabama	Lincoln, AL	Honda's largest light truck production facility in the world, and we're the sole manufacturer of the Odyssey minivan, Pilot sport utility vehicle, Ridgeline pickup truck, the Acura MDX and the V-6 engines that power them.
Auto Manufacturer	Hyundai Motor Manufacturing	Montgomery, AL	Assemble the Hyundai Sonata and Elantra and their 4 cylinder engines. The plant is capable of producing up to 399,500 vehicles per year at full capacity.
Auto Manufacturer	Hyundai Motor Ulsan Plant	Ulsan, Korea	The world's single largest automobile plant, sitting on 1,200 acres and is Hyundai Motor's main production plant, comprising five independent plants. It employs over 34,000 workers capable of producing 5,600 vehicles daily.
Auto Manufacturer	Mercedes Benz Factory	Vance, AL	Build the M-Class, R-Class, GL-Class and C-Class vehicle. Annual production in excess of 300,000 vehicles, 70% of which are exported.
Defense Contractor	Northrop Grumman Electronic Systems	Lithicum, MD	Leading developer, manufacturer, integrator and supporter of a variety of advanced electronic and maritime systems for U.S. and international customers

			for national security and non-defense applications
Defense Subcontractor	Kongsberg	Johnstown, PA	An international technology corporation that delivers advanced and reliable solutions that improve safety, security and performance in complex operations and during extreme conditions.
Government Agency	National Institute of Standards and Technology (NIST)	Gaitherburg, MD	A non-regulatory federal agency within the U.S. Department of Commerce. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.
Government Depot	Letterkenny Army Depot	Letterkenny, PA	The depot of choice for Industry, Government, and the Greatest Warfighters in the world by delivering superior maintenance, manufacturing, logistics, life cycle support and service worldwide to the Joint Warfighter and our International partners.
Korean Government	Defense Acquisition Program Administration (DAPA)	Seoul, Korea	Established on January 1, 2006, to enhance the transparency and to block the vicious cycle of corruption related to acquisition, through fundamental reformation of the defense acquisition field.

Korean Government	Korean Trade Investment Promotion Agency (KOTRA)	Seoul, Korea	Contribute to the development of the national economy by performing research, pioneering of new markets, gathering information about overseas markets to promote national trade and foreign investment; promoting overseas public relations on behalf of domestic industry, products and Korean foreign investment environment; intermediation in trade transactions, and investment cooperation and industrial technology transactions between domestic and foreign firms
Manufacturing Panel	Manufacturing Association of South Central Pennsylvania	PA	C501 non-profit focused on business development, workforce training, education, and development, human resource consulting, and legislative advocacy
Manufacturing Panel	National Center for Defense Manufacturing and Machining (NCDMM)	Blairsville, PA	Deliver optimized manufacturing solutions that enhance the quality, affordability, maintainability, and rapid deployment of existing and yet-to-be developed defense systems. Collaborate with government, industrial, and academic organizations to promote the implementation of best practices to key stakeholders through the development and delivery of disciplined training, advanced technologies, and methodologies.

Metal Job Shop	Clark Metal	Blairsville, PA	Help companies successfully design and manufacture products. As an advanced manufacturing company and a proven leader in metal fabrication, our flexibility optimizes product designs, ensures product quality, reduces product costs, and gets you to market faster
Metal Powder Producer	North American Höganäs	Hollsopple, PA	Utilizing the endless opportunities of metal powders, to lead a wave of change for the better.
Metal Producer	Carpenter Latrobe Specialty Metal	Latrobe, PA	Leader in the development, manufacture and distribution of cast/wrought and powder metal stainless steels and specialty alloys.
Metal Producer	Hyundai Steel	Dangjin, Korea	Strengthen national competiveness by resolving domestic shortage of steel supply, facilitating the development of steel technology, and meeting the demands of high quality steel products used for vehicles.
Non-Profit	Lightweight Innovations for Tomorrow (LIFT)	Detroit, MI	A public-private partnership to develop and deploy advanced lightweight materials manufacturing technologies, and implement education and training programs to prepare the workforce.
Railway/Rolling stock producer	Hyundai Rotem Changwon Factory	Changwon, Korea	Manufacture and operation of rolling stock and railway systems production of ground weapon systems, manned and unmanned weapon systems, construction of steelmaking facilities, car manufacturing plants, and environmental plants

Tool producer	Kennametal	Latrobe, PA	Deliver productivity to customers seeking peak performance in demanding environments by providing innovative custom and standard wear-resistant solutions. This proven productivity is enabled through our advanced materials sciences and application knowledge.
Truck manufacturer	Volvo	Hagerstown, MD	Manufacture Volvo D11, D13, and D16 engines and Volvo I-Shift automated manual transmissions.

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